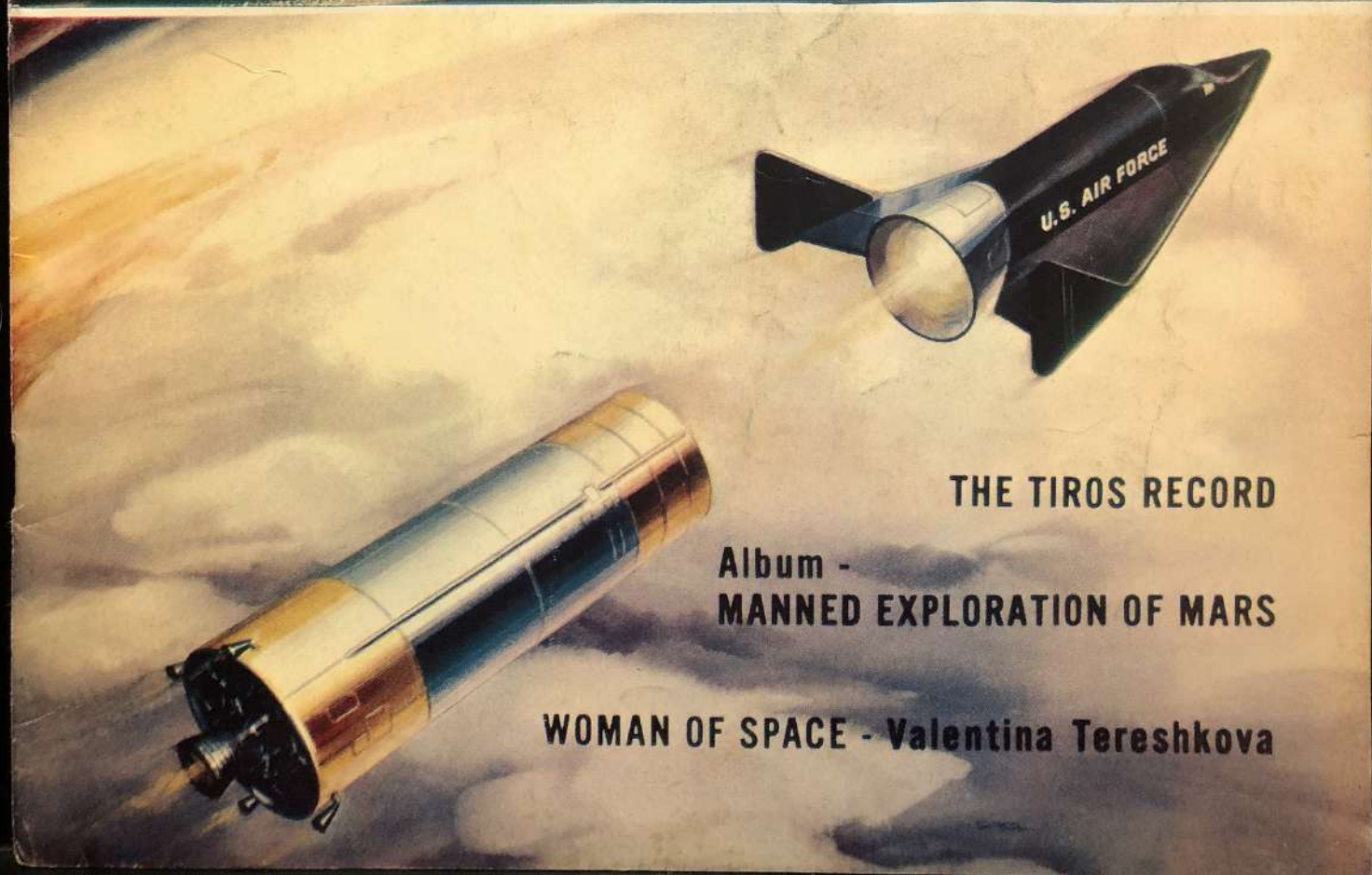


SPACE WORLD

The magazine of space news

Sept.-Oct. 1963

50c



THE TIROS RECORD

Album -
MANNED EXPLORATION OF MARS

WOMAN OF SPACE - Valentina Tereshkova



WOMAN OF SPACE

OUR CONTEMPORARY

By Yuri Gagarin,
Commander of the Unit of Cosmonauts

"I know this wonderful girl for little over a year," Yuri Gagarin told a Novosti Press Agency (APN) correspondent, "but it seems as though we've been acquainted since childhood. She put together cord rings at a tyre factory, operated a machine tool at the Krasny Perekop Mill, worked as a YCL leader of Yaroslavl textile hands, and showed herself to be a bold sky-diver. She may have been a classmate of mine at a factory apprenticeship school, and sat at the same desk with me in an industrial training school, because she is our contemporary.

When Valya joined our unit, all of us liked her at once. By us I mean not only the flyers and instructors, but also our wives. She entered our unit like one enters his own family - simply, not showing off, firmly determined to fall in with the traditions existing in our unit, and, if she were able, to introduce something of her own, something new.

This young woman, with kind eyes, a charming smile, unobtrusive feminine beauty, never hid her disappointment on meeting with failure, but she never allowed herself to be in low spirits. We already grew accustomed to her gaiety in our friendly company. I'll also admit that she greatly touched us by her filial concern for her mother. We met her sometimes at the post office, which meant that she hurried to send a letter or a part of her pay to her mother.

And another thing that won us over was her industriousness. When she got a new flat, she went there straight from practice, hitched up her skirt, and washed, scrubbed and cleaned every inch of the rooms.

To be a cosmonaut calls for something else besides fearlessness; you won't get very far only

with daring. To be a cosmonaut means to possess knowledge and ability. I watched her at practice and in class a great deal. It was hard for her to master rocket techniques, study spaceship designs and equipment, but she tackled her assignment stubbornly, devoted much of her own time to study, poring over books and notes in the evening. She was never embarrassed putting questions to teachers and to the cosmonauts, both those who had and had not been out in space.

To a fledgling cosmonaut, as, incidentally, to a "veteran", the gym is a place where strenuous and persevering effort is put in. The set of exercises doesn't give anyone a chance to relax. You have to work hard, and can't drop practice until you've polished all elements. Keeping an eye on Valya in the gym, I always am amazed by both her physical stamina and envious persistence.

We're always extremely grateful for the attention and care shown by the doctors, who get us in trim for flights, but, I'll admit, that we sometimes grumble at being forced to do the same tests over and over again, to repeat the same experiments. Watching Valentina at training, I cannot but be surprised by her attention, by her boundless desire to carry out all the orders of the doctors and instructors to the best of her ability.

Apart from natural excitement and feelings of pride for our Valya, I really am sorry that her father cannot see her today; he gave his life early in the last world war. He would have blessed his daughter as she set out to accomplish her exploit in space, and once again tell the world how we all hate war, which takes away our near and dear ones.

I don't know whether Valya is

thinking about this, but I picture her flight as a splendid gift to the women of the globe, who will shortly get together in Moscow for their World Congress. They give life to people, and it's their right to fight for the triumph of life, for our children and the future children of



Medical test.

our glorious Valentina (I wish her many, many of them) to live under the clear sky of our wonderful planet, the Earth.

A woman in outer space! Herein lies a remarkable and convincing manifestation of the amazing changes which have occurred in the life of the peoples of our country in 45 years of Soviet government. In order to send a woman up in a space flight, it was necessary to spur previous generations to creative efforts, to give them ample room at work, in science, and society. All this has been accomplished by my country, by my people, by my Party. Today they can say proudly: "Our daughter is out in the cosmos. Happy flying to you!"

BIOGRAPHY OF

Who is she, this girl, whose exploit has not only brought fame to the Soviet people, but also to all the women on earth, the better half of the human race?

Here is the biography of the 26-year-old pilot of the Vostok-6 spaceship, which today flew off to follow Valeri Bykovsky, already out there in space.

She was still a child when she lost her father. He perished in the very beginning of World War Two.

The year when the war ended saw Valya start going to school. After finishing a seven-form school, she went to work in the Yaroslavl Tyre Factory to help her mother and simultaneously continued her education in the eighth form of a night school.

A few months later she changed over to the Krasny Perekop Mill where her mother and older sister, Lyudmila, were employed. There she acquired the trade of a coarse linen loom operator. It was at this mill that she joined the Young Communist League, enrolled in a correspondence technical school, and took a fancy to sky-diving.

Her friends nominated her as a member of the mill's YCL Committee, and in 1960, she became the Committee Secretary. That same year she graduated the technical school as a cotton-spinning expert. At the air club she qualified as a Sky-Diver, First-Class.

This biography is ordinary, typical of many of her coevals. Valya was respected at the mill for her industriousness, ready sympathy, and kind heart. They respected her boldness and perseverance. Valya was always the gaysoul of any company.

She joined the unit of valiant cosmonauts simply, without showing off. She won everyone over by her modesty, and persistent efforts to master the complicated techniques of space flight.

Naturally, these qualities did not come by themselves, but developed as the girl moved along the

VALENTINA TERESHKOVA

roads of life. From her mother, Elena Fyodorovna, she inherited diligence, the ability of appreciating the joys of life and not complaining about hardships. The main thing was her desire to study, study and study.

To be left a widow with three little children to care for is difficult for any woman. It was harder still for Valya's mother, Elena Fyodorovna, because she had no education and no profession.

"My friends, everyone at the mill helped me look after the children while I was at work and every time I was in need," Elena Fyodorovna said.

Valya learned many things at school. She saw what wonderful opportunities unfold before every Soviet boy and girl. But, probably, the decisive role in moulding Valya's character was played by her friends at Krasny Perekop. The workers there, who came from generations of textile hands, take very good care of the young people who come to work with them.

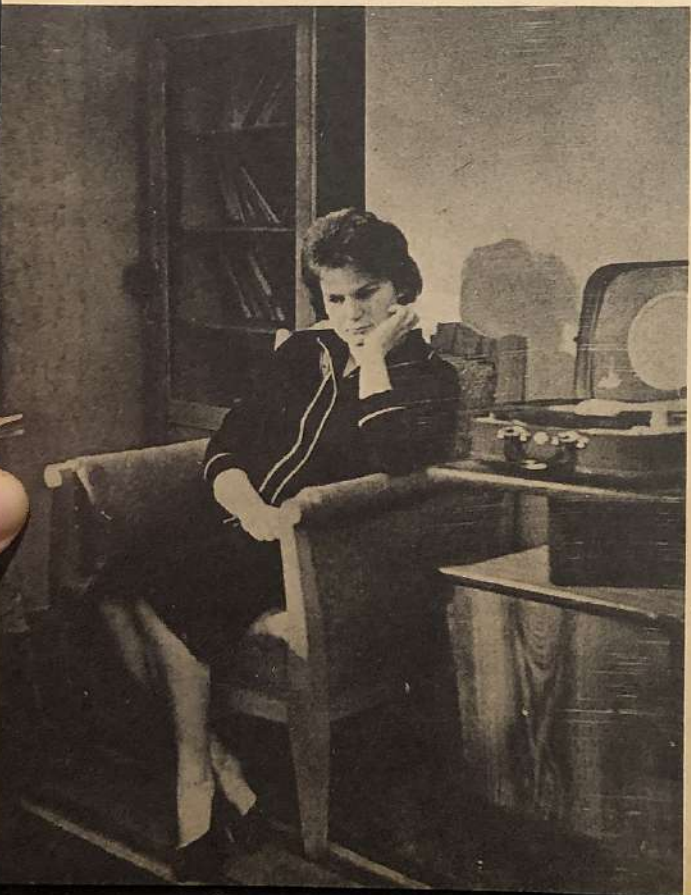
The coarse linen loom department, which Valya joined as an apprentice, helped her acquire her new trade swiftly. When the young girl was elected secretary of the mill's YCL Committee, elder comrades supported her in all undertakings. There was plenty to do. The young mill hands took part in building new houses, running Pioneer camps in the country, making the mill grounds and club more attractive, and helping out in the construction of an oil refinery, announced in the city as a priority job.

Valentina matured together with her comrades. She was accepted as a candidate member of the Communist Party of the Soviet Union in February, 1961, and in March the following year, on the eve of her joining the unit of cosmonauts, she was admitted as a member of the Party.

A Soviet woman, a working woman, a young Communist - this is who is piloting the Vostok-6 spaceship. All this is a sign of our times.



At training.
At home listening to music.



After Space Flight. Driving to Red Square.

BELOW: Valya and Margaret Russel, head of American delegation at World Women's Congress, at the reception in the Kremlin.



SPACE SUITS

By

James V. Correale, Head, Crew Equipment Branch and
Walter W. Guy, Head, Systems Analysis Section

The goal of NASA to land a vehicle and place an astronaut on the surface of the moon has brought the space suit out of the comic strips to reality. Few realize, however, that in 1934, Wiley Post first entertained the idea of breaking the high-altitude record with the use of what might be termed today, the granddaddy of space suits. Wiley's suit was a simple rubberized inflatable garment. The suit had virtually no mobility, with the arms designed to assume a fixed position of stick and throttle enabling him to control the aircraft marginally. Also, there was no effort made to provide any comfort facilities. However, Wiley's suit, though primitive in comparison to our present-day, Wally's (Schirra) suit, did what it was required to do. It provided Post with the protection he needed to fulfill his mission - that of attaining a new altitude record. Since that time, engineers and scientists of the Department of Defense, NASA, and industry have been trying to overcome the two major difficulties of complete mobility and comfort. The question of complete mobility is a complex design problem within itself, notwithstanding its being compromised by the comfort criteria which impose numerous problems to the space suit design engineer. For the purposes of clarification, comfort is interpreted to include suit fitting as it relates to pressure points; thermal balance as provided by the environmental control system in conjunction with the suit ventilation distribution efficiency; and perhaps the most complex, that of waste management. Mobility is interpreted as those functions required by the astronaut to complete a mission either in an unpressurized or a pressurized state, whether it be vehicular or extravehicular. The development of one suit to meet the aforementioned general requirements for all missions would con-

stitute major breakthroughs; and design achievements for items, although desirable, are not specifically required for the mission intended. In this respect, the philosophy for suit design was selected to be mission oriented, with mission time and spacecraft compatibility as paramount parameters.

Project Mercury

The Project Mercury suit (fig. 1) is utilized in the same manner as the Navy Mark IV suits are used in fighter aircraft: that of an emergency garment, a backup to spacecraft integrity. The design of the spacecraft controls and limited amount of space available to the astronaut, reduced the mobility requirements to the areas of the shoulders and hands. Waste management in the short-term mission is satisfactorily accomplished by proper dieting and the use of a well-designed, constant-wear urine-collection device. The one primary role the suit does play is providing temperature control by an efficient ventilation distribution system. The system is such that oxygen is led into the suit via a torso-located connector and distributed to the extremities. A percentage of this gas is bled directly to the torso area. All the flow is then exited through a headpiece connector back into the environmental control system. This system has permitted Mercury to operate with cabin temperatures approaching 100 degrees plus 5 degrees F. In view of the short-term capabilities of Mercury, major emphasis was placed on unpressurized comfort. This comfortable environment was accomplished by trade-offs in ventilation distribution in which the number of lines and subsequent routing of the lines were minimized. The suits were also individually tailored to eliminate bulk and possible pressure points caused by folds from

excess material.

Project Gemini

Looking toward Project Gemini, which will have mission potentials of up to 14 days, some of the short-term design advantages gained in the Mercury suit are lost. In Project Gemini, some of the problems presently confronting suit design are: provision for thermal protection as required in the event of a pad abort and suit ejection seat interfaces needed to provide a satisfactory escape capability. These are but a few of the additional design problems; however, though difficult, we may consider them as exterior to the suit, and we are still faced with the man-suit habitability problem, only to a much greater degree than in Project Mercury. Considering the confinement of the two-man Gemini spacecraft and the long-term mission capabilities, NASA is developing a partial-wear space suit (fig. 2). Interesting features in this concept are that the headpiece and arm and leg sections of the suit can be removed within the confines of the spacecraft. These components may be easily replaced in a minimal period of time and will provide protection in an emergency. This capability is undoubtedly a recognized comfort advantage. The ventilation system is designed in such a manner that the gas enters at the waist into a chamber, is distributed directly to the facial area, arms and legs, and then exits at the waist, as opposed to Project Mercury in which the gas exited through the helmet. This routing eliminates the possibility of the astronaut in-

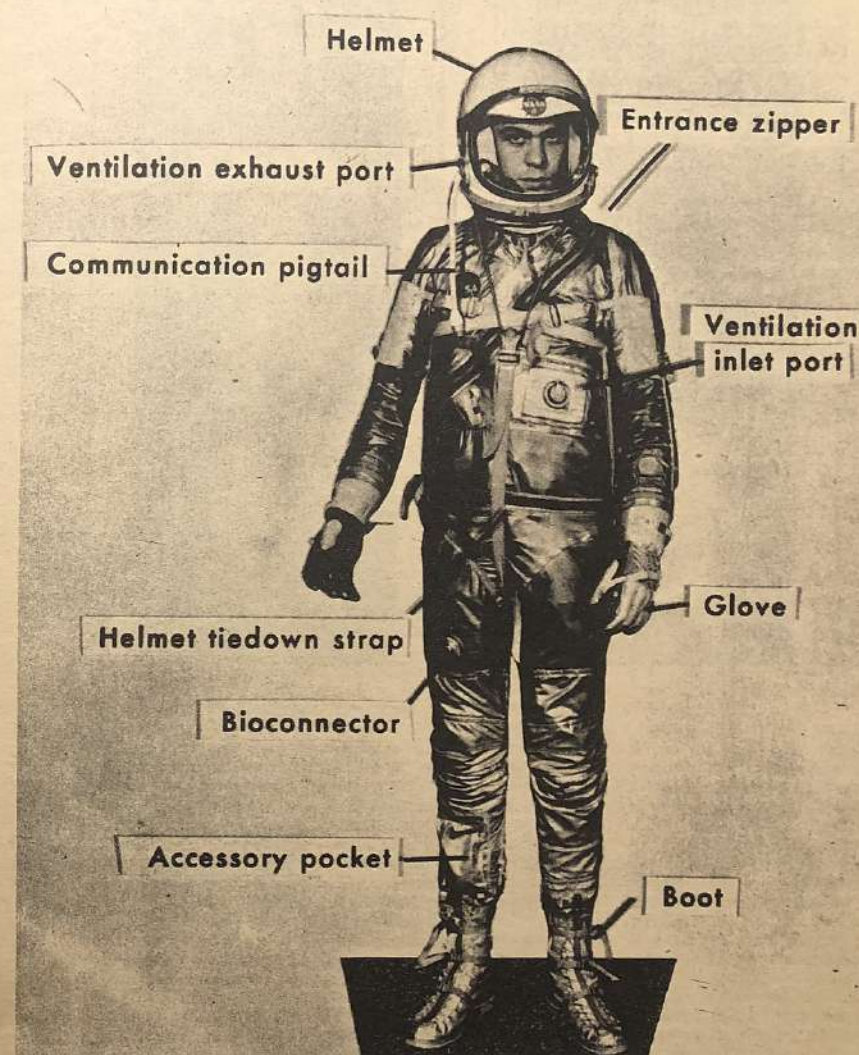


Figure 1.- Mercury pressure suit

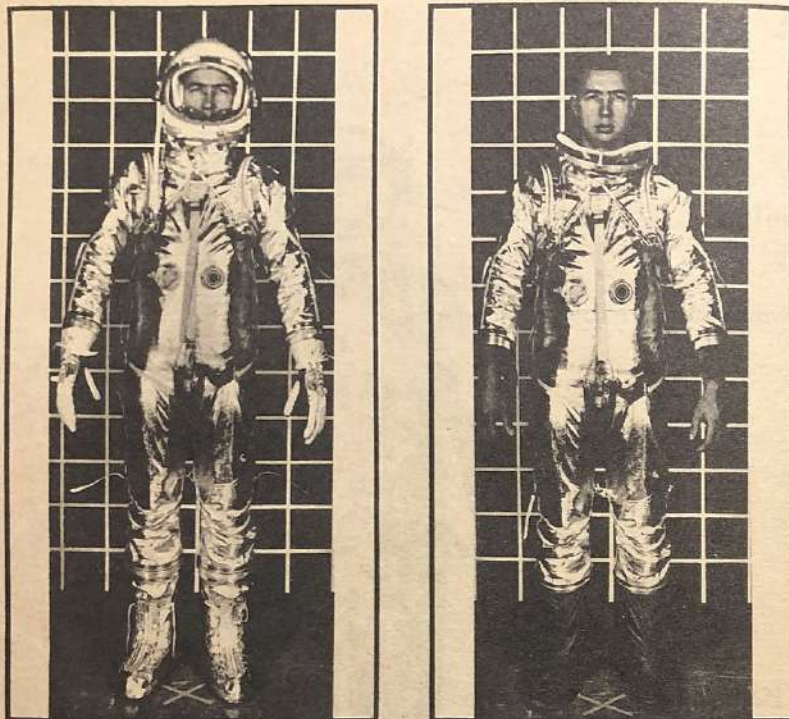


Figure 2.- Partial wear concept of space suit, prototype Gemini

haling toxic gases or body odors. The ventilation system is such that when the headpiece is removed, pure oxygen is continuously directed toward the oral-nasal area. Since the partial-wear concept continuously encumbers the astronaut with the torso section of the suit, the matter of waste disposal still remains a difficult one. Donning of the suit is accomplished primarily by the pressure-sealing entrance zipper. The entrance zipper runs from just below the abdomen through the crotch and up the back of the suit to the helmet combination bearing disconnect. Thus, this zipper also serves as the access portal for purposes of urination and defecation. Early in the program, it was determined that a body-waste collection system, as an integral part of the ejection seat, could seriously compound the seat design and delay the program. In view of this, a

program was initiated in which prototypes of what might be termed a "defecation mitten" are presently being evaluated for usage in the confines of the Project Gemini spacecraft. The one-handed collection device is simply managed, has a self-contained germicide and can be easily sealed and stowed after usage. The dual-purpose donning zipper access portal makes possible the elimination of a constant-wear urine-collection device, as in Project Mercury. Once the craft is in orbit, the collection device utilized during the time on the launch complex is removed and subsequent elimination is uniquely transferred into the environmental control system. The transfer method will also allow for the collection of samples for postflight analysis.

Evaluation programs are being initiated to determine water requirements and metabolic outputs of

a Gemini suited subject in the completely donned versus the partially donned condition. These programs will be conducted under various simulated activity levels and environmental conditions. Spacecraft and suited-subject compatibility tests (presently in the preliminary stages) are being conducted to assess the extended wear acceptability for periods of 2, 7, and 14 days. Emergency pressurization time will be included to simulate abort situations.

Before dealing with the Project Apollo space suit it should be clear that although our suit programs are project oriented, much of the data gained from utilization of both the Mercury and Gemini suits and the developments acquired, will be a strong foundation for the Apollo suit program.

(Project Apollo suit next issue.)

SPACE INDUSTRY MOURNS VON KARMAN

By Don Hanson

"We started to work on rockets as a group of graduate students and a few other young men... we had come upon the Cal Tech campus name for this group - the Suicide Club - because we went out to the arroyo with primitive rockets, and like all children who are playing with fire, and especially playing with rocket fire, were in danger."

It was a fond memory, relished in the telling, as Dr. Theodore von Karmán reminisced through the history of rockets, missiles, and of Aerojet, the firm he founded, on the company's 20th anniversary last

year. The Aerojet Engineering Corporation to do the job.

"These events are very near to my heart," he said as he told the whole story into a tape recorder a year before his death.

How near Theodore von Karmán himself was to the hearts of the leaders of today's aerospace industry was seen at his funeral on May 14.

He died in Aachen, Germany, busy with one of his many favorite programs - the Aeronautical Research and Development Advisory Group of NATO, which he had organized 10 years ago. In the week following, men who had looked to him as both friend and teacher gathered in grief at his home in Pasadena from around the world.

They were men like Cal Tech's Lee DuBridge, and scientists, industrialists, and military men. Aerojet was represented by a large group headed by Honorary Chairman of the Board A.H. Rude, Board Chairman Dan Kimball, President W.E. Zisch, and Secretary T. E. Beehan.

To each one, von Karmán was a personal friend. To them, the usual von Karmán descriptives ("brilliant," "genius," "father of aerodynamics") weren't enough. Most of them couldn't find words that were enough.

But there was an out-pouring of memorial comments:

★ From President J.F. Kennedy - "It is with regret that I have learned of the death of Dr. Theodore von Karmán, to whom only last February I awarded the first National Medal of Science... I know his friends and associates will mourn his loss and join me in paying tribute to a great scientist and humanitarian."

★ From Dr. Werner von Braun - "All of my associates join me in expressing the great personal loss that we feel in the death of Dr. von Karmán, who was a great pio-

neer in aerodynamics, aeronautics, and the related disciplines."

★ General Tire President M.G. O'Neil - "All of us in the General Tire organization regret the loss of the greatest of the original pioneers in jet propulsion, space penetration and missile development."

"His contributions to the world of science will be reflected in great benefits to all future generations... We know how much he will be missed by all his friends."

★ Aerojet Board Chairman Dan A. Kimball - "Dr. von Karmán's death is a matter of deep personal regret to me and an irreparable loss to the world of aerospace science."

"His contributions to aeronautics and to the space age made him a foremost international figure. Aerojet will always be grateful for the part he played in the development and growth of the company."

★ Aerojet President W.E. Zisch - "The world's scientific community has suffered a great loss in the death of Dr. von Karmán. My association with him for more than a quarter of a century both at Cal Tech and at Aerojet gave me a deep respect for his towering genius."

"Aerojet will continue to be guided by the principles on which he founded the company and through which it has developed and prospered."

★ W.H. Pickering, President of the American Institute of Aeronautics and Astronautics - "Dr. von Karmán's passing leaves what may well be a permanent void in the U.S. and international aerospace community. It is doubtful that ever again one man will influence this field as much as this great scientist, engineer, educator, humanitarian, and international personality."

Comment, yes. But all, admittedly, inadequate expression of the real void left by Dr. Theodore von Karmán, 1881-1963.



VON KARMAN

year.

Excerpts from his recollections then serve now as a memento of the wit, warmth, and wisdom of the great scientist, who died May 7, just four days short of his 82nd birthday.

Looking back then, he remembered the first successes with JATO by that Cal Tech "Suicide Club." He recalled the search for someone to produce the jet-assist take-off rockets for the pre-World War II air force, and the later decision to

ALBUM

As a special feature of this issue of Space World we present a series of reproductions suitable for your space library or scrap-book. This is the first of a regular series which will appear in Space World.

The reproductions following are examples of the beautiful art work of General Electric's talented artist Roy Scarfo. His art work has appeared many times in Space World and the August 1961 issue featured Mr. Scarfo in an article titled "Space Artist at Work."

Comments and captions are by Advanced Nuclear Systems Engineering of General Electric.

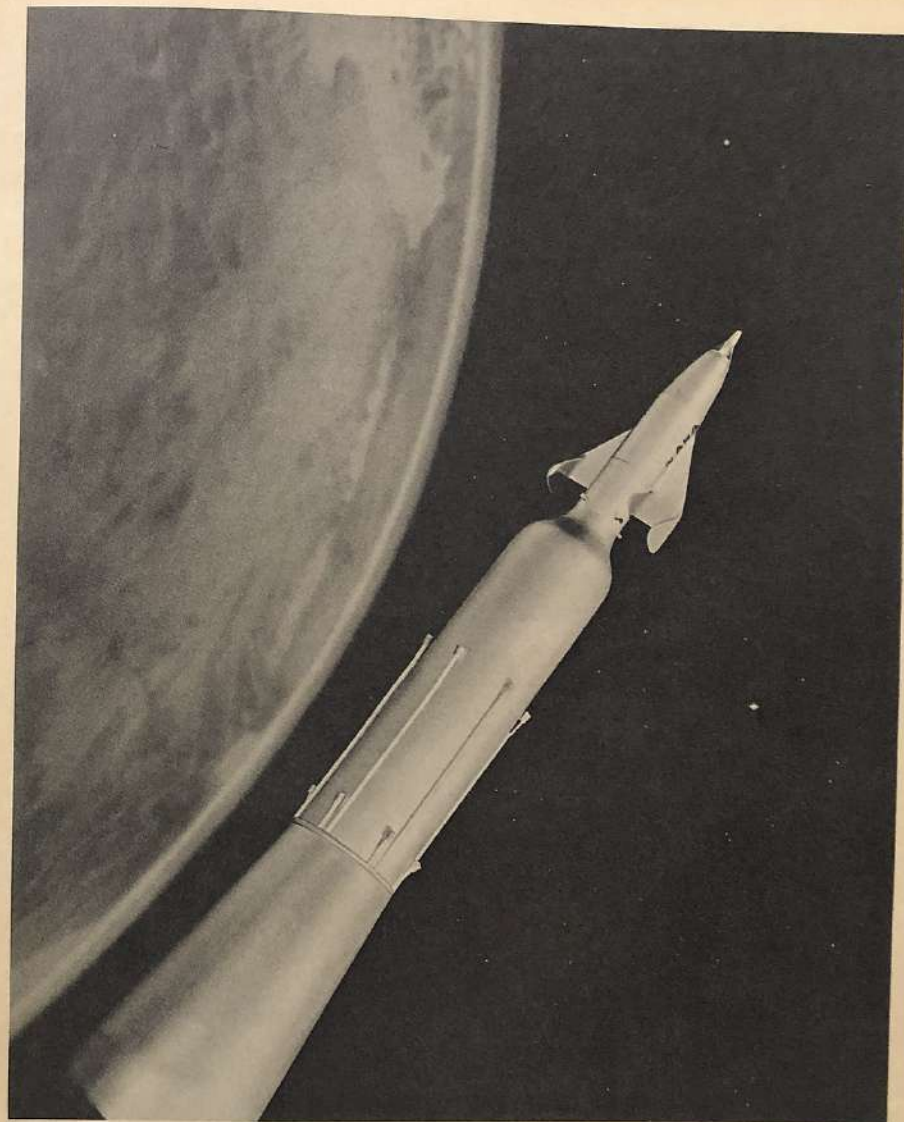
NUCLEAR ROCKET SPACECRAFT for MANNED EXPLORATION OF MARS



A nuclear rocket propelled spacecraft for manned exploration of Mars is described by the accompanying sequence of photographs. The vehicle is sized for a 15 month mission with four crewmen, assuming a favorable opportunity such as that afforded by departure in April of 1971. Propulsion is supplied by a 130,000 pound thrust heat transfer nuclear rocket with specific impulse of 820 seconds. The engine uses a fast spectrum refractory metal core, a type of core which offers great promise for manned interplanetary missions, due to its inherent re-start capability and resistance to fuel clad erosion for long burning times.

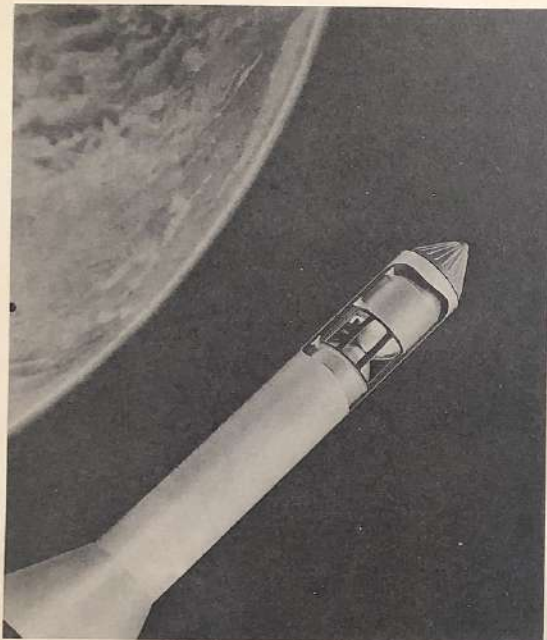
Long engine life and multiple restart are extremely important factors in reducing gross vehicle weight, since they permit a low initial thrust to weight ratio (small engine), and eliminate the need for staging engines after each firing interval. Furthermore, the smaller size of a fast metallic core provides an engine weight advantage of at least two to one over a thermal-graphite core engine of the same thrust rating. Smaller core frontal area also permits a similar reduction in shield weight.

The spacecraft gross weight of 880,000 pounds in Earth orbit is divided so that four Saturn V boosters can be used for the initial launching. A basic propulsion and payload module is orbited by one of the boosters, and the remaining three launch vehicles will each carry four loaded propellant tanks. The tanks rendezvous with the propulsion module to permit Earth orbital assembly of the interplanetary spacecraft. Additional features of the design are described in conjunction with illustrations of the vehicle as it would appear in each mission phase.



The propulsion and payload module is shown in its launch configuration. The hydrogen tank and chemically propelled Mars excursion module will permit the landing of a two man exploration party, after the spacecraft has attained Mars orbit.

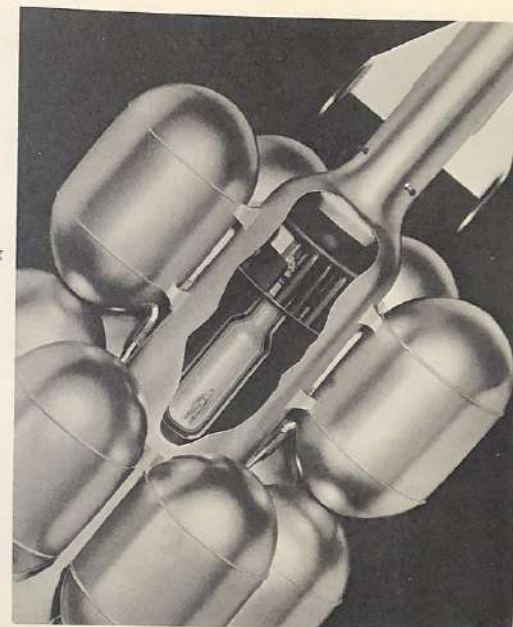
Attached to the forward end of the tank, a chemically propelled Mars excursion module will permit the landing of a two man exploration party, after the spacecraft has attained Mars orbit.



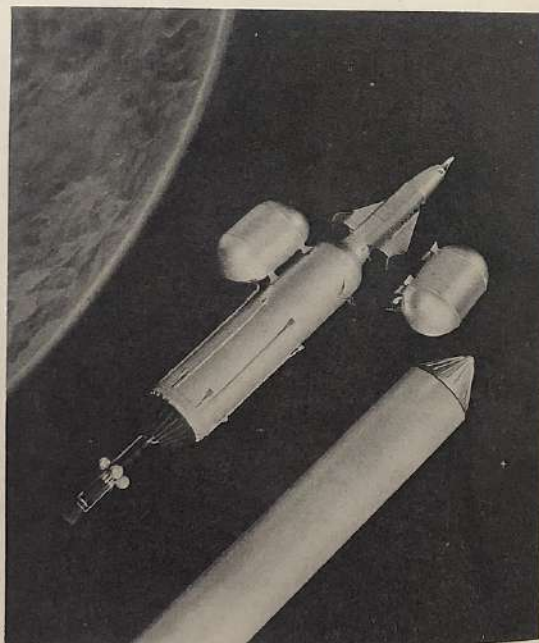
One of the three tanker vehicles is shown in the launch configuration. A structural shell supports four nearly spherical tanks, each of which contains over 45,000 pounds of liquid hydrogen. By employing auxiliary structure to reinforce the tanks during booster ascent, the weight of the tankage can be minimized. After installation on the nuclear rocket spacecraft, the light weight tanks will be exposed to only moderate accelerations (less than 1g), rather than the 7 or 8g experienced in attaining initial orbit.

In this view, the general arrangement of the crew quarters can be seen. A two deck command module will contain the life support systems, living accommodations, communications gear, experimental equipment, and a control center. Solar flare protection is provided by a vacuum jacketed capsule projecting downward into the main hydrogen tank. This "storm cellar" is lined with carbon shielding to augment the 8 foot thick annulus of liquid hydrogen which surrounds the capsule. Shielding is designed to restrict the integrated crew dose to less than 100 Rem for the complete mission.

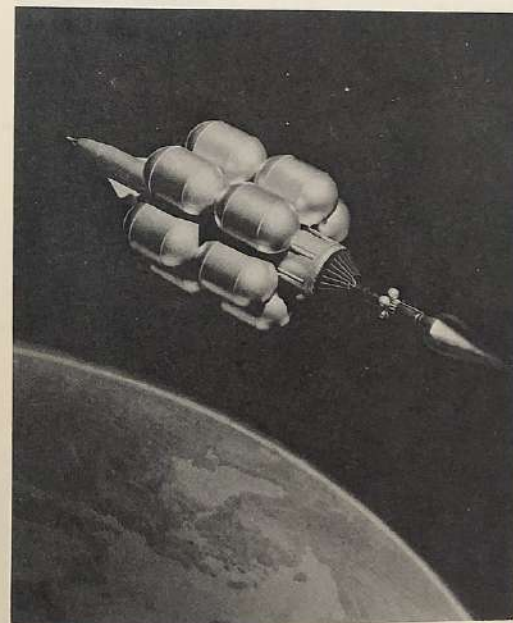
Note that the proposed configuration does not provide an artificial "g" capability. If zero "g" cannot be tolerated for the long duration of an interplanetary mission, a rotating cabin section could be factored into the design. However, this approach would result in a substantial increase in spacecraft gross weight due to structural integration problems with an artificial "g" design.

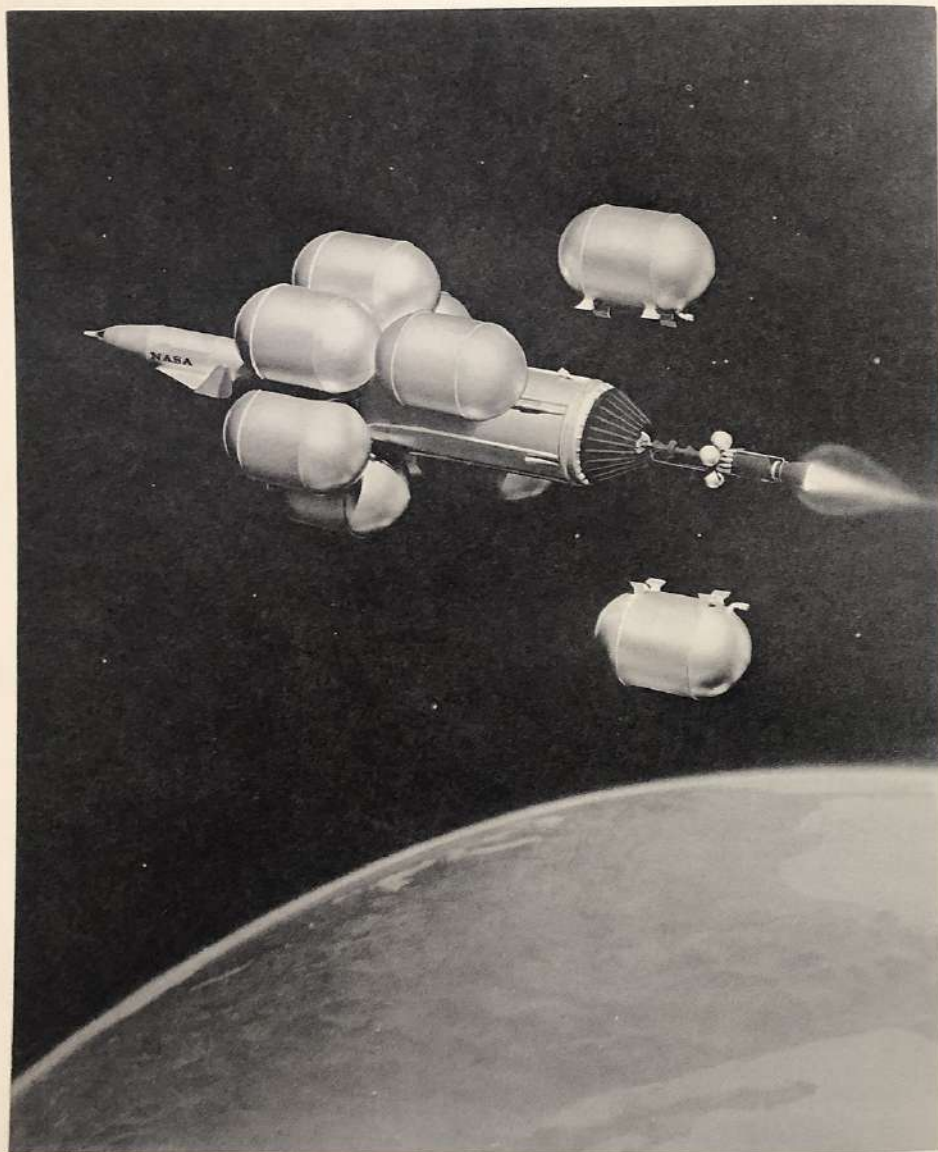


In this illustration, the separable hydrogen tanks are being attached to the propulsion module in low Earth orbit. Each tank is insulated with multi-layer radiation foils to minimize hydrogen boil-off. In addition, a cryogenic re-condensation system may be employed for those tanks which are not emptied until the later phases of the mission. This system would be powered by a SNAP-8 or SNAP-50 type of nuclear electric generating system located between the main propulsion reactor and the aft end of the central tank. The radiator for the SNAP powerplant can be seen just aft of the tank. In practice, it may be necessary to move this radiator into a position well to the rear of the rocket engine during coast periods, so that heat load on the hydrogen tank will be minimized. An attractive possibility exists for eliminating the auxiliary power reactor by integrating a liquid metal heat exchange loop with the rocket reactor core. This approach not only reduces system weight, but also tends to minimize the problem of after-heat removal from the engine.



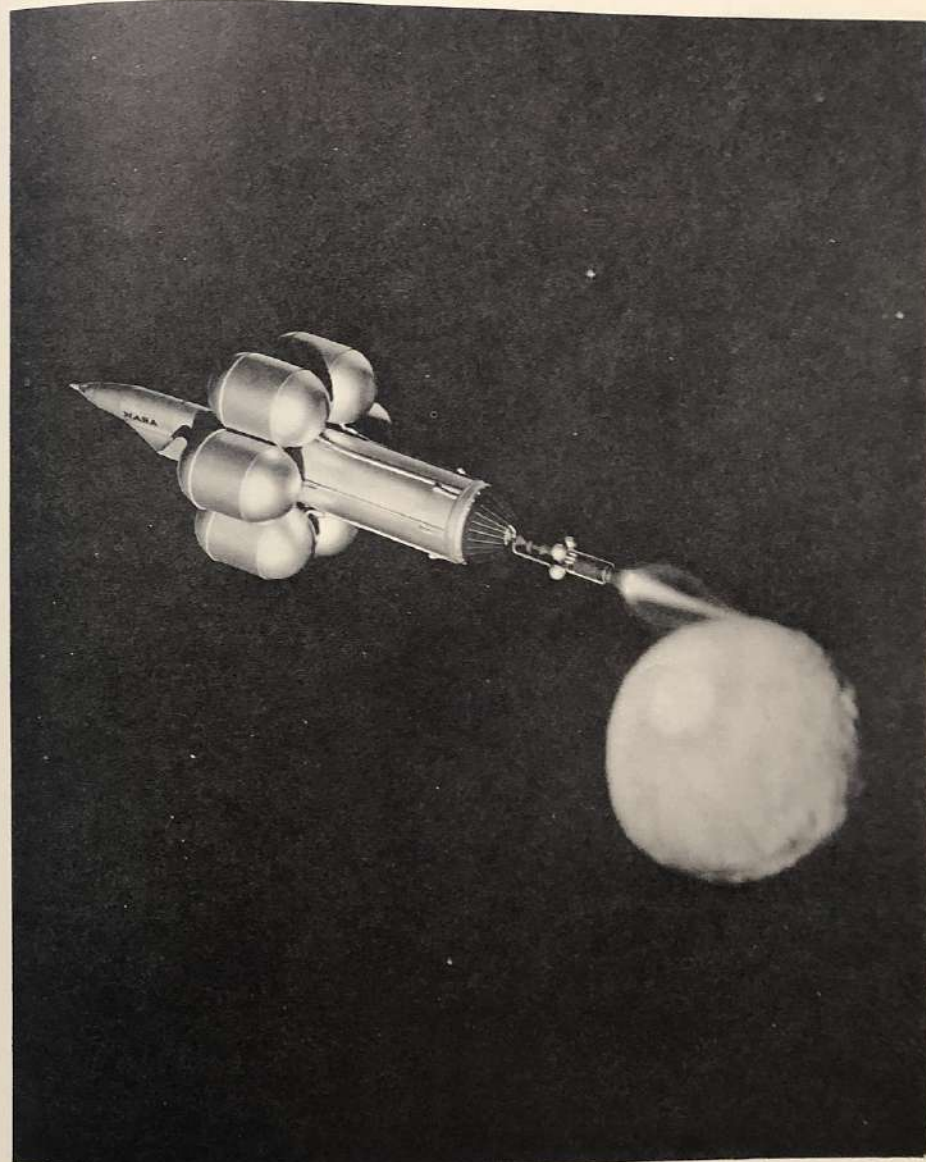
The orbital launch maneuver is shown here. A total of six tanks will be emptied to depart from Earth orbit and achieve the Mars transfer ellipse. In the event of an abort during the escape maneuver, the chemically propelled Mars landing craft could be used for return to Earth orbit.





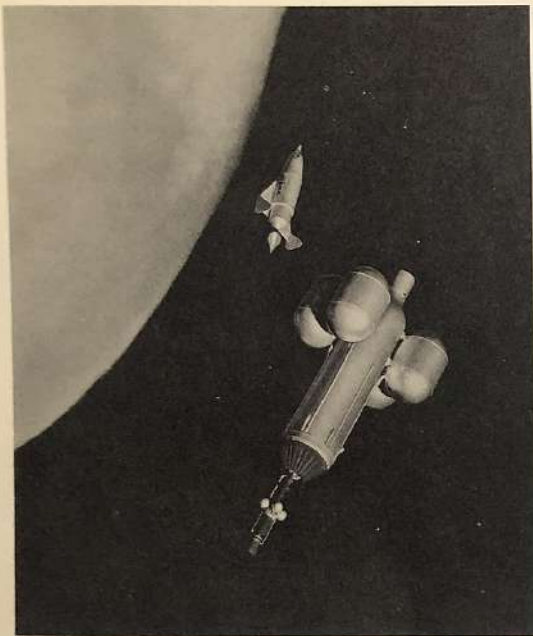
Staging of tanks during Earth escape propulsion is shown. Total propellant consumed up to injection for the Mars transfer is about 140 tons. In coast configuration two of the six tanks emptied during Earth escape will remain attached. This provides a degree of redundancy against the possibility of a

meteoroid puncture in any of the loaded tanks, since propellant could be transferred into the remaining empty tanks. If no puncture occurs, the empty tanks are released immediately prior to the firing interval for Mars capture.



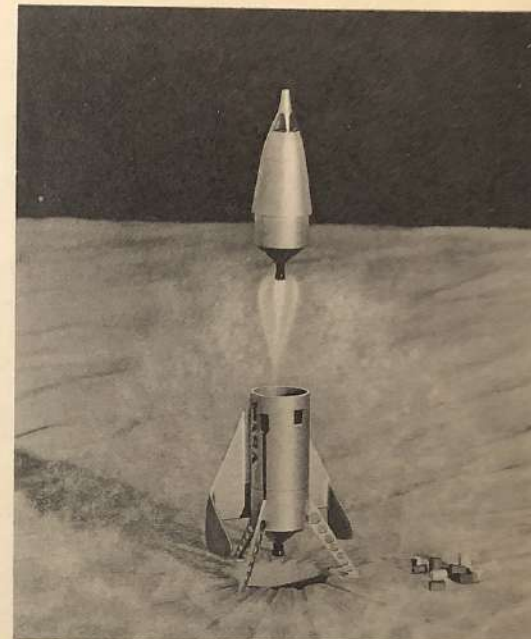
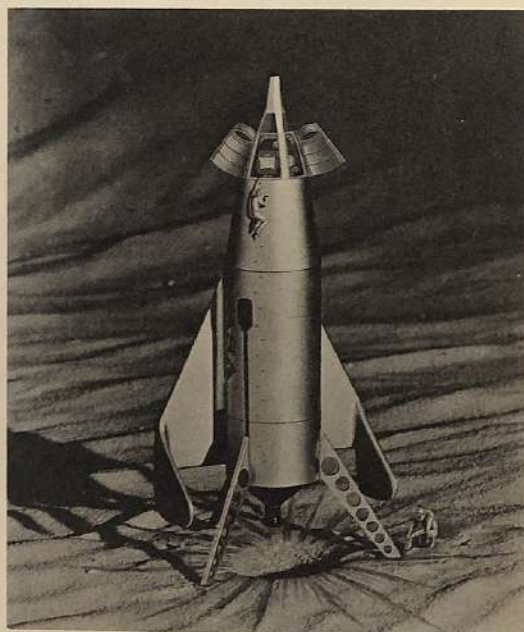
The Mars capture maneuver produces an eccentric orbit of about 200 miles perigee and several thousand miles apogee; thereby minimizing propulsion requirements, while still providing a close view of the

planet for final evaluation of landing sites. Four of the last six external propellant tanks are emptied during capture, but only two are jettisoned. Two are retained for meteoroid puncture redundancy until just before the Mars escape firing interval.

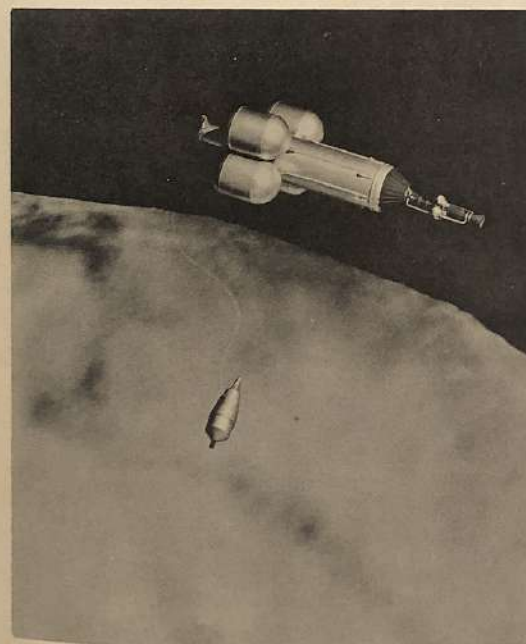


After transferring to the Mars excursion module, two of the four crew members fire braking rockets to bring the entry vehicle orbit perigee into the planetary atmosphere. The major portion of the deceleration is then accomplished by aerodynamic drag. After maneuvering to an altitude of a few thousand feet, the landing craft is maneuvered into a vertical attitude for final approach. One minute of hovering capability allows for some possible changes in landing site, and three shock absorbing struts are extended for the final touchdown. The winged entry vehicle represents only one of several possible shapes, and lenticular or conical configurations might also be employed, depending upon the degree of aerodynamic maneuvering desired during entry.

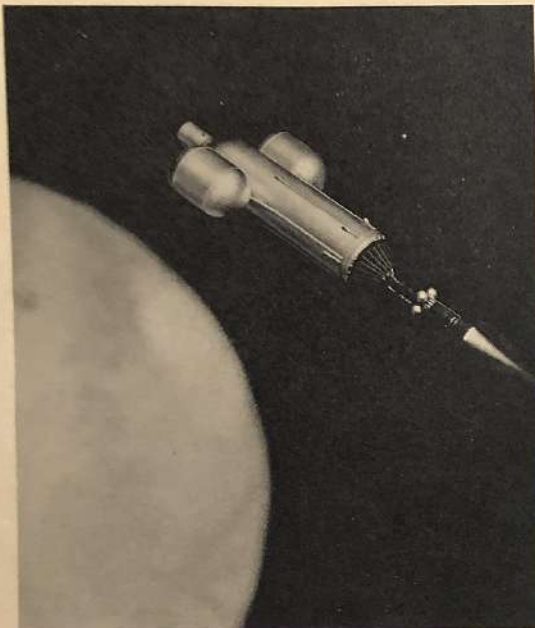
The Mars excursion module is shown in its landing position. In addition to the two man crew capsule, approximately 5000 pounds of scientific equipment and portable life support gear can be transported to the Martian surface. Gross weight of the excursion module prior to departure from orbit will be about 35,000 pounds if hydrogen oxygen propulsion is used. Stay time on the planet is restricted to about 5 days, due to limited payload and the rapid deterioration in launch window for the Earth return phase of the mission.



All equipment, except for the minimum life support capsule and a few hundred pounds of soil samples, will be abandoned on the surface. The chemically propelled second stage of the landing vehicle uses the first stage structure as a launching platform for the return to Mars orbit.



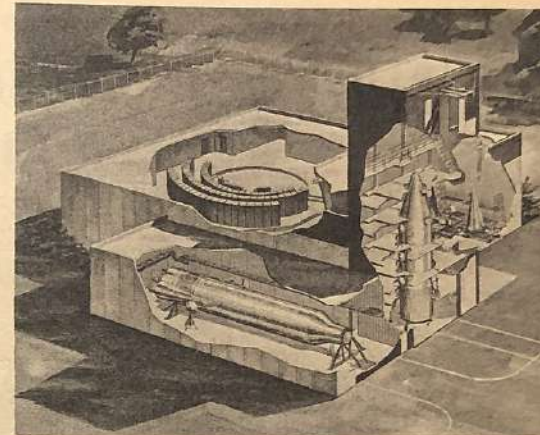
After rendezvous with the nuclear rocket spacecraft, the excursion module second stage is abandoned in the eccentric parking orbit.



This illustration shows the Mars escape configuration of the spacecraft. During this maneuver, the last two external tanks are emptied, as is the aft compartment of the main tank. The forward end of the main tank, which surrounds the solar flare shelter, still contains hydrogen throughout the Mars-Earth transfer.

MOON FLIGHT REHEARSAL

**\$6.8-million Facility
to be Built**



Artist's concept depicts Atlas/Centaur/Surveyor rehearsal lunar mission in \$6.8-million flight simulation facility soon to be constructed at General Dynamics/Astronautics, San Diego. The new facility, called Combined Systems Test Stand (CSTS) will accommodate all stages of the moon-bound vehicle for unified ground testing.

Centaur/Surveyor vehicles destined for exploratory flights to the moon will first rehearse each mission in a \$6.8-million flight simulation facility at General Dynamics/Astronautics, San Diego, Calif. The facility is designated Combined Systems Test Stand. It is now in the design stage and is scheduled to support Centaur/Surveyor development missions in 1964, and lunar flights beginning in 1965.

Cost of the test stand will include a structure with 22,000 square feet of floor space, plus test equipment. Construction is scheduled to begin during the third quarter of this year on a 3 1/2-acre site adjacent to General Dynamics/Astronautics.

Centaur is the first U.S. hydrogen-fueled space vehicle. It is being developed for the National Aeronautics and Space Administration (NASA) by General Dynamics/Astronautics under the direction of NASA's Lewis Research Center, Cleveland, Ohio.

Surveyor will use scientific equipment, including television, to explore the moon. It is being developed for NASA by Hughes Aircraft Co. under the direction of the Jet Propulsion Laboratory, Pasadena, Calif.

The entire moon-probe vehicle—consisting of an Atlas first stage, a Centaur second stage, and the Surveyor spacecraft—will be inte-

grated within the test stand for flight simulations. The Combined Systems Test Stand will be the first known facility designed specifically to accommodate all stages of a space vehicle for unified ground testing.

"With this test capability, we can assure that systems on all stages are compatible and functioning together as required before shipment to Cape Canaveral," explained Grant L. Hansen, vice president and Centaur program director. He said delivery of totally tested, flight-ready vehicles to Cape Canaveral will reduce preflight test time at the launch complex. This will insure that the vehicle is ready for flight at the required time, he said.

Hansen cited the test stand as another example of the scope and intensity of the Centaur ground test program. He said NASA, when announcing assignment of the nation's highest priority to Centaur, stated it would be the most thoroughly tested space vehicle in history.

In the Combined Systems Test Stand, the Atlas launch vehicle will be horizontal. Centaur, with Surveyor mounted on top, will stand vertically near Atlas. All three stages will be mated electrically and will function as if actually united.

During the tests, the vehicle systems will perform the majority of their flight operations, except actual engine ignition, just as they will during an actual prelaunch

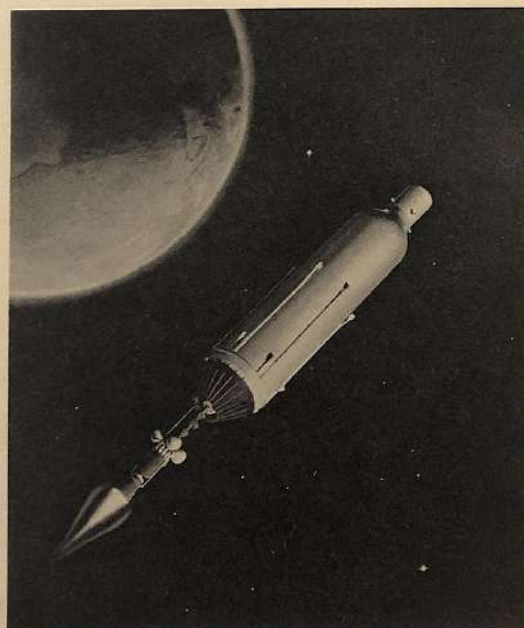
countdown and flight.

"As far as the vehicles are concerned, they will be operating on an actual flight to the moon," Hansen said. "Guidance will maintain course, autopilot will direct required flight sequences, telemetry will broadcast vehicle performance data, and engines of both Atlas and Centaur will actually gimbal as if maintaining attitude and course control."

General Dynamics/Astronautics will operate the test facility for NASA. The test crew will include personnel from NASA, General Dynamics, Hughes Aircraft, and the Jet Propulsion Laboratory. Selected members of the flight team from Cape Canaveral also will participate in the testing to familiarize themselves with the vehicle before launching it to the moon.

Test personnel will conduct the flight simulations from a control center nearly identical in appearance and equipment to the blockhouse at Cape Canaveral. Ground support equipment used in the test stand will closely duplicate counterpart equipment at the actual launch complex.

An interim combined systems test facility is now being prepared at General Dynamics/Astronautics to check out the Atlas/Centaur combination, but without the Surveyor spacecraft. It will serve until the new test stand is completed.



Upon approaching Earth, the two empty tanks are released, and the nuclear rocket engine is used to brake the vehicle into a high altitude parking orbit. The crew will then transfer to a ferry vehicle for Earth re-entry. Alternatively, it would be possible to reduce the velocity increment required of the interplanetary spacecraft by employing direct re-entry from the Mars transfer ellipse. However, this would require that an Earth re-entry vehicle be transported through the entire mission, thereby increasing the weight carried on the spacecraft. Since direct re-entry alleviates the need for a large propulsion maneuver at the terminal end of the mission, little or no propellant would be available for solar flare shielding during the return flight coast period. The flare shield weight would then have to be increased to insure crew protection in the "empty" vehicle.

THE

MAN-ROCKET

By Robert D. Roach, Jr.

One of man's ageless dreams - unencumbered free-flight by a man utilizing an integrated propulsion system - was realized April 20, 1961. Early that chilly morning, a small dedicated group of men gathered on the fringes of Niagara Falls Airport, New York. Here in a community better known for its scenic display, engineers of many disciplines have long worked to harness nature's power. This was the setting for the demonstration of man's first controlled, individual, freeflight with a Rocket Belt, a further conquest of nature's physical constraints.

Man's first Rocket Belt flight, traversing more than 100 feet, at an altitude best measured in inches, was the culmination of an eight month development program conducted by Bell Aerosystems Company for the the United States Army Transportation Research Command.

The desire to fly has appealed to man since he first noticed the birds, the flight of objects through the air and harboured the thought of reaching the heavenly bodies. A well-known legend of personal flight tells of Daedalus and Icarus who tried to fly with wings constructed of feathers and wax. Icarus flew too close to the sun, the wax melted, and he perished from his fall into the sea.

Early inventors experimented with kites, gliders, flapping wings. Leonardo da Vinci even conceived a fundamental helicopter design. Cyrano de Bergerac, Jonathan Swift, and later, Jules Verne, described concepts of aircraft, spacecraft, and even satellites.

Free flight with lighter-than-air craft was achieved in 1783. Powered flight of a heavier-than-air craft did not occur for another 120 years.

Now, in the dawn of the space age, it is ironic that man would pause to fill in one of the blanks in flight achievement that was passed over in the rapid aero and astro progress of the twentieth century.

Recent attempts to provide personal propulsion centered around flying platforms and one-man helicopters. The thought of affixing a rocket to a man's back was neither new, nor was it untried by the time Wendell F. Moore, a rocket engineer at Bell Aerosystems Company, first gave it serious thought in 1953.

During the hey-day of amateur rocketry in Germany in the thirties, an enterprising, fearless young man, outfitted with a rocket on his back, attempted to zoom through the streets on roller skates. The bruises he sustained from being cartwheeled and dragged across the ground, discouraged further rocket excursions by skaters.

But Wendell Moore's idea was to join man with a rocket and accomplish flight of this integrated man-machine, supported by the rocket thrust alone. Assigned to Bell's X-airplane programs at Edwards Air Force Base in California, Moore scratched the first "engineering drawings" of the belt in the desert sands with a pointed stick, while he discussed his man rocket concepts with Jim Powell, Bell's flight research engineer for the X-2 rocket -powered aircraft.

Unstable Man

Man is not a very stable flying object! Therefore, stability and control presented a much more severe technical challenge than the development of the rocket propulsion system.

In order to obtain basic information on stability characteristics, to determine where the thrust nozzles should be positioned, and to what portion of the human body the lift force should be applied, a nitrogen gas test rig was constructed. Made entirely of steel tubing, the test rig had two underarm stirrups to lift the operator.

A flexible hose, draped over a 15-foot high support, delivered the nitrogen to the tubing at a point above and behind the operator's head. From there, the flow was divided equally to both sides of the man at approximately shoulder height, where two downward-pointing tubes were fitted with flow control orifices.

Operation of the device was controlled by a test engineer on the ground by means of a valve which increased or decreased nitrogen flow through the lift device nozzles. The system was crude, and its limitations were readily acknowledged. The flex hose would restrain the freedom of movement of the rig; the nozzles might be mismatched thrust-wise, and the operator could only attempt to control in one plane,

pitch, by fixed arm pieces attached to the tubing to permit rotation of the rig about the shoulderline.

On a cold day in the winter of 1958, with the ropes tied about his waist and lines from them running fore and aft to several stalwart gentlemen, in order to control any



This is an award winning essay written by Robert D. Roach, Bell Aerosystems Co. for the Goddard Historical Essay Contest.

This historical essay documents the development of the Rocket Belt invented by Wendell F. Moore.



Technician Gordon Yaeger adjusts rocket belt on Courter.

violent maneuver, Wendell Moore signalled thumbs-up - "take it on up." The blast was ear shattering. The dust really flew. The control valve was a bit too coarse in furnishing thrust corrections resulting in some rapid up-and-down maneu-

vers. But, it was a beginning. Jim Powell, returned to Bell's Niagara Frontier plant, took a turn at it and tried to translate fore and aft by tilting his arm-control levers. The success of such maneuvers was not readily measured because of all of the hose and flex hose restraints. At this point, one very important factor in the philosophy of flight by man-rocket couples was dramatically portrayed for the group at the test site.

Jim Powell had been through a check-out ride on the jet platform with which the National Advisory Committee for Aeronautics had been experimenting at Langley, Va., and he reported that to translate fore and aft or to the sides, it almost sufficed to "think" about the direction of travel in order to move that way.

When another Bell engineer with convictions of instability in such a man-machine configuration attempted to "fly" the nitrogen test rig, he made repeated attempts to get up to an altitude of several feet. Each time he went through violent side-to-side swings accompanied by over-corrective foot motion on his part, which only aggravated the condition of instability. His flying-belt career drew to a close quickly when on one violent side swing, he dashed himself against the wall! Fortunately, he was not injured, but he was more convinced than ever that the arrangement was unstable. Then the Bell motion picture photographer who had been recording the tests, Tom Lennon, volunteered to take a brief ride in the "rig".

Lennon gave the "thumbs-up" signal, and away he went - five, ten, almost fifteen feet into the air - up, then down; up again, down and up for the next three minutes without the slightest hint of instability. This experience with different operators with the same equipment and at the same time, indicated that even though a stable configuration might be forthcoming in the actual Rocket Belt designs, operator attitude would play a significant role in success or failure.

The work with the nitrogen rig established the feasibility of under-arm lifting for a Rocket Belt and hinted that stable operation could be achieved. Some insight on proper nozzle location was gained when a



With both hands grasping the motor cycle type throttles of the rocket belt, test engineer, Harold M. Graham, travels through the air under the power of the jet rocket propulsion system strapped to his back.

rocket engineer managed to have the sleeves of his sport coat unraveled by the jet blast while he was in flight. The hazard would be much greater, of course, when the actual hot gases from a rocket were employed in the prototype designs. So, the nozzles were deployed further from the operator's body and canted outward.

Army Interest Mounts

Army interest began to mount about this time. While Wendell Moore and Jim Powell took up another assignment for Bell in Baltimore, Maryland, there was a request for proposals for a study program for a Small Rocket Lift Device. A contract for the study program went to Aerojet-General Corporation. By the time that the study program was complete, and the configuration for

a SRLD (small rocket lift device) for manned flight had been defined, Wendell Moore was back at Bell's main plant rekindling an interest in the next phase of the U.S. Army's program. Phase II was to be the fabrication of the SRLD, and a manned flight program, first on a tether (safety harness) for the safety and experience, then finally to negotiate free and controlled flight.

A contract award was received from U.S. Army TRECOM (Transportation, Research and Engineering Command) in August 1960. Project Officer for the Army was Robert Graham. This was to be a minimum cost feasibility program, so Wendell Moore, now technical director for Bell's program, set out to use proven "shelf" items such as oxygen breathing bottles, for propellant and pressurant tanks.

Moore was an inspired man—the job was one that he wanted, earned, and cherished. This was not just an indifferent run-of-the-mill engineering assignment. Moore selected Eddie Ganczak as the Project Engineer, and Ernie ("the Bear") Kreutinger, as the rocket technician and general "man-Friday". Others, too numerous to mention, participated throughout the development program.

Fabrication Begins

Initial SRLD design configurations were compatible with the recommendation of the Aerojet study, and so, with approval of the Army, fabrication was initiated. A 280-pound thrust rocket motor was constructed and tested. This unit would supply hot gas to the nozzles on each side of the SRLD. A throttle valve, resembling the one designed for use by the Astronaut in the Mercury Capsule manual reaction control system, was selected as controller. The valve was operated through cable linkage with a squeeze throttle located on the operator's right arm rest. The left arm rest was lifted with levers to operate jetavator type gas deflectors around the nozzles to effect yaw.

Mating of all of this machinery with the man was a minor challenge. A major concern was the support of the 125-pound loaded weight of the propulsion system. A form-fitting fiberglass corset was made to the body contour of the first intended operator—and this, of course, was an honor (at that time a dubious one) reserved for Wendell Moore.

Following the practice of having a "roll-out" ceremony for flying machines, the SRLD or rocket belt was not to be denied this bit of aerospace tradition. Amid the clicking of photographic shutters, Ernie Kreutinger donned the hardware, added his trademark, a baseball cap and a big cigar, and alternately positioned himself to provide a "3-view".

The test program was laid out in an intelligent, walk-before-you-run, manner. First, the peroxide rocket was test fired, the control valve was flow tested, and the full system was installed in a rocket test cell with a remote control linkage to operate the throttle. The

assembly was allowed to move up and down on guide wires and it was ballasted to equal full launch weight of the man-machine combine. As testing progressed and confidence increased, Wendell Moore positioned the SRLD in a holding fixture and backed up to it so that he could operate the controls from the same position as in flight. Satisfied with the rocket propulsion system, the time had come for the final assembly of this mostly human flying machine.

Donning a special set of protective coveralls and a crash helmet, Moore was carefully tethered at the waist as a safety precaution during tests.

Since a lower tether attached to his legs proved too restricting, it was removed and tethered flights continued in the less congested out-of-doors. It was winter and the rapid condensation of the steam produced billowy white clouds which obscured observation of the operator.

The remaining tethered flights were made in the hangar in which they had originated. After 15 or 20 tethered flights, Wendell Moore had located many bugs in the system. A tendency to yaw (rotation of the operator about his vertical centerline) was one of the most difficult stability problems to overcome. The jetavators gave the best control in the yaw direction. While experimenting with the effects of forceful body movements, Moore would occasionally induce a pendulum movement of his body which could not easily be stopped. During these maneuvers he adopted a practice of cutting the rocket thrust and allowing himself to be supported and lowered on the tether line.

Tether Breaks

One morning while he was approximately 10 feet above the concrete hangar floor, he cut the rocket power expecting to be lowered by the tether. Unbeknown to the flight test crew, the tether line had been sawing back and forth on a sharp metal bracket on the propulsion system. At rocket cut-off, with Moore's full weight on the line, it failed, and he fell to the floor sustaining a fractured knee cap. His subsequent permanent grounding deprived him of total fulfillment with his project—a free-flight.

Harold Graham, a 27-year-old



Courter soars over an automobile.

rocket test engineer, volunteered and was selected to fill the breach. Graham had worked with some of the SRLD components, so was not entirely unfamiliar with the program. This meant that Graham would start cautiously with tethered flights and gradually build up the experience required for the first free-flight.

After 36 tethered flights, Harold Graham had conducted final de-bugging flights, practiced landing let-down procedures, and evaluated the installation of additional pads and supports under arm and at the waist as well as an abdominal support plate suggested by Dr. F. Tyler Kelly, the plant physician. Dr. Kelly's contribution soon became known as the "Kelly Belly Plate."

Graham's proficiency and confidence grew with each succeeding flight, and on the morning of April 20, 1961, all conditions were "go" for an attempt at free flight. Everyone on the field had an assigned task. Observers were positioned along the flight path, as were motion

picture and still photographers. Dr. Kelly was on hand to get the operator's vital capacity, and blood pressure and pulse measurement, both before and after the flight. Ed. Ganczak was running through the check list, a practice well defined by experience during 56 previous tests. Ernie Kreutinger stood close by with a hand type fire extinguisher to act in the case of leakage and consequent fire.

The check list run-through was now complete. Ganczak accepted the safety locking pin from the throttle control and signalled Harold Graham that he was on his own. The tanks were pressurized and Graham flexed his arms and back muscles to ascertain the familiar feel of his 125-pound propulsion system. He was ready. Whoosh! A short burst to check out the operation of his propulsion system, but only for an instant, and insufficient in thrust to move him. Now, satisfied that both he and the equipment were ready, he applied the throttle, rose to a height of about 18 inches and im-

mediately began translating forward at about 7 to 10 miles per hour.

The rapidly condensing steam in the cold air obscured the operator from view until he began to move along the flight path. Photographers rushed alongside to get an unobscured shot. On a nearby highway, cars came to a rapid halt while amazed early morning travelers became eye witnesses to history. When he touched down proudly at the end of his 112-foot flight (eight feet less than the Wright Brothers first powered flight) Graham had been airborne in free and controlled flight for 13 seconds. Man had written a new chapter in the conquest of nature!

This, of course, was merely a beginning. A number of flight accomplishments were to follow in the remaining month the initial Army contract was to run. Graham flew up and over a 30-foot hill with an approximate 60-degree slope while maintaining a flight path approximately parallel to the ground at an altitude of three to four feet. He flew across a 12-foot wide stream of water, made circular flight paths, flew over obstacles such as trucks, and slammed through a course of flags.

Public Debut

The first public demonstration requested by the Army on June 8, 1961, at Fort Eustis, Virginia, brought national acclaim to this humble SRLD program.

While Harold Graham flew over an Army 2 1/2-ton truck, the G.I. driver relaxing comfortably in the cab, the crowd of several hundred officers, VIP's, and guests watched awestruck. The moment he landed, as with every single SRLD flight that had ever had an audience, the crowd broke into spontaneous applause - and Graham's reply was a jaunty salute thrown from his white helmet. Within a week after this first public unveiling, "The Belt," as even the average citizen was calling it, was readied for a performance on the Pentagon lawn. Approximately 30 general officers and an estimated 3,000 other Pentagon workers took a ten minute break to witness the Army's newest method of mobility on parade. For this particular demonstration, Graham flew high over an Army staff



car which had been purposely placed as an obstacle in his flight path. The flight was perfect, the applause thunderous, and - Graham's salute was improving.

The flights conducted in subsequent months were many and varied. To learn more about the stability and control characteristics, test flights were instrumented and data was telemetered to a ground station. Meanwhile, requests were filled, with Army approval, for numerous public appearances throughout the country. Thousands of other requests to demonstrate the Rocket Belt at state fairs and even on a worldwide tour had to be denied for economic reasons.

Company mail contained unsolicited ideas which ranged from totally ridiculous to criminally suspicious. One gentleman demanded his own Rocket Belt so that he could put his hands on a \$1,000,000 treasure which, he said, could not otherwise be reached. Such a request could not be granted, of course, due to the experimental nature of the SRLD. But one cannot help but wonder whether the walls of Ft. Knox might not have been the obstacle in mind!

Graham went on to complete 83 free flights with the rocket belt and

retired from the program. Although never seriously injured during his tenure, he did have a few bad spills and collected many bruises. Perhaps his most memorable flight was a command performance for President John F. Kennedy at Fort Bragg, North Carolina. As Graham flew from the deck of an off-shore amphibious vehicle to land in front of the President, he tossed off one of his now perfected salutes. The President returned it in fine Navy style.

Research Continues

Interest still runs high in the potential applications of the Rocket Belt for tactical and rescue missions by the U.S. Army and others. Now a second generation of Rocket Belt operators are trained and are continuing the research necessary to make this device a successful military tool. The two current Rocket Belt pilots at Bell Aerosystems Company present a study in contrast.

Youngest is Peter Kedzierski, 19, who finished an aviation mechanics course in a vocational high school and was doing some additional study there when Bell Aerosystems Company selected him to train to be a Rocket Belt pilot.

The second operator, Robert F. Courter, Jr., is a 36-year-old veteran pilot with combat flight experience in World War II and Korea.

For the future, the prospect of more Rocket Belts and more trained operators is already beyond the planning stage. Only time will tell the extent of the role to be played by this man-machine mode of flying in the future of man's transportation. Some see it as the answer for the traffic-jammed commuter. Others see humane rescues from points of difficult access.

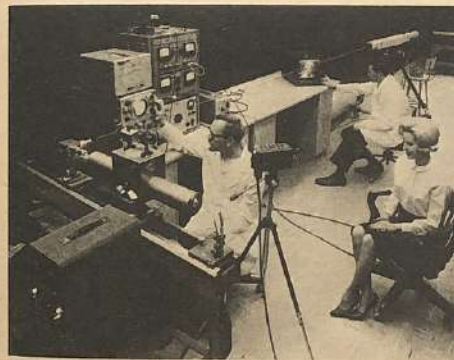
The 1965-1980 era brings with it a need for man to maneuver about in space or on lunar or planetary surfaces. The Rocket Belt fulfills these needs. It can be compacted to a light weight installation, since the thrust required for movement through vacuum at zero gravity is extremely minute.

But whatever the future, the past was a dream from the dawn of man, and 1961, the year which saw the first suborbital flight of a Mercury Astronaut will also be remembered for the Rocket Belt.

(Eds Note: We believe there should also be pics of beautiful women in Space Magazine. Here are three examples why we believe America has the most beautiful women in the world.)

NEWS PHOTOS

Mrs. Norma Wilson of the Martin Company is holding a battery similar to those planned for use in NASA's Nimbus weather satellite. The company will employ a new method to test nickel-cadmium batteries. Goal of the program will be to develop more dependable power systems for satellites. The gauge is for test purposes only.



A continuous beam of light, generated by a helium-neon gas laser and directed into a hand-size "optical modulator" (left), carries a television image in a demonstration at North American Aviation's Space and Information Systems Division. (Sorry, we don't have the name of the gorgeous blond.)



Pretty Dorothy Colton of Atomics International compares the size of a bowling ball with a dummy uranium casting which would weigh the same. Depleted uranium, a byproduct of nuclear fuel manufacture, is one of the most dense materials known. It makes excellent counterweights and balances for missiles and aircraft as well as specialized radiation shields.

Nov.-Dec. 1963

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SPACE WORLD

The magazine of space news

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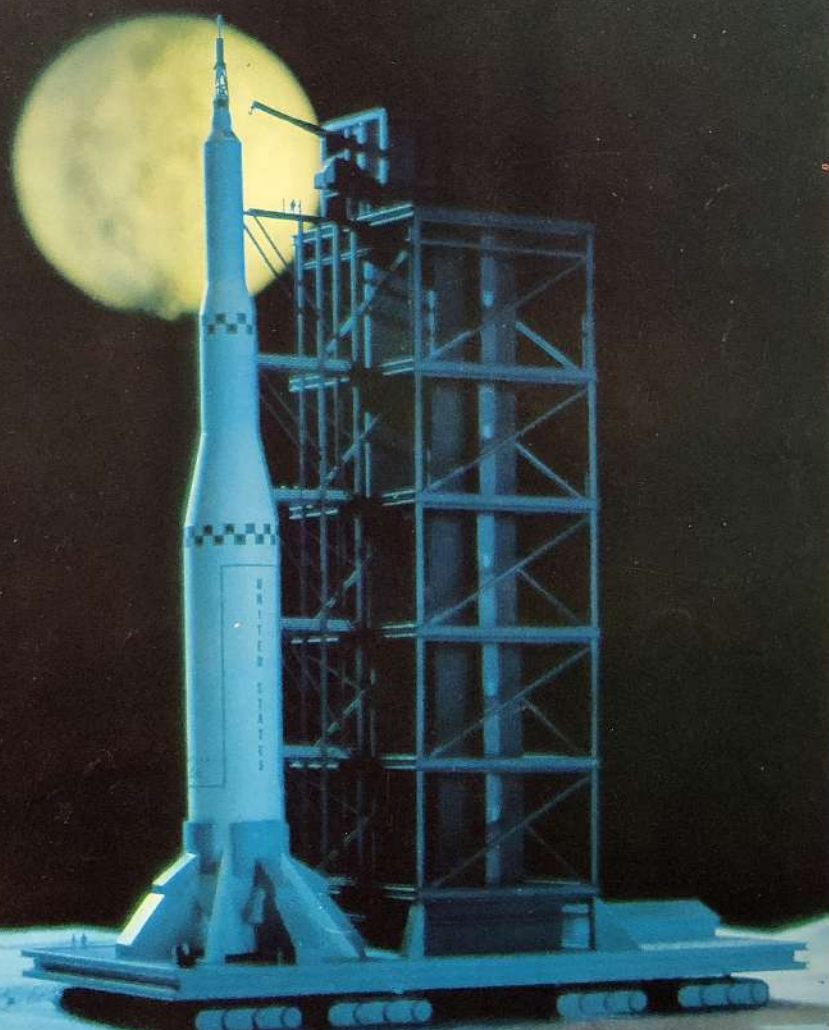
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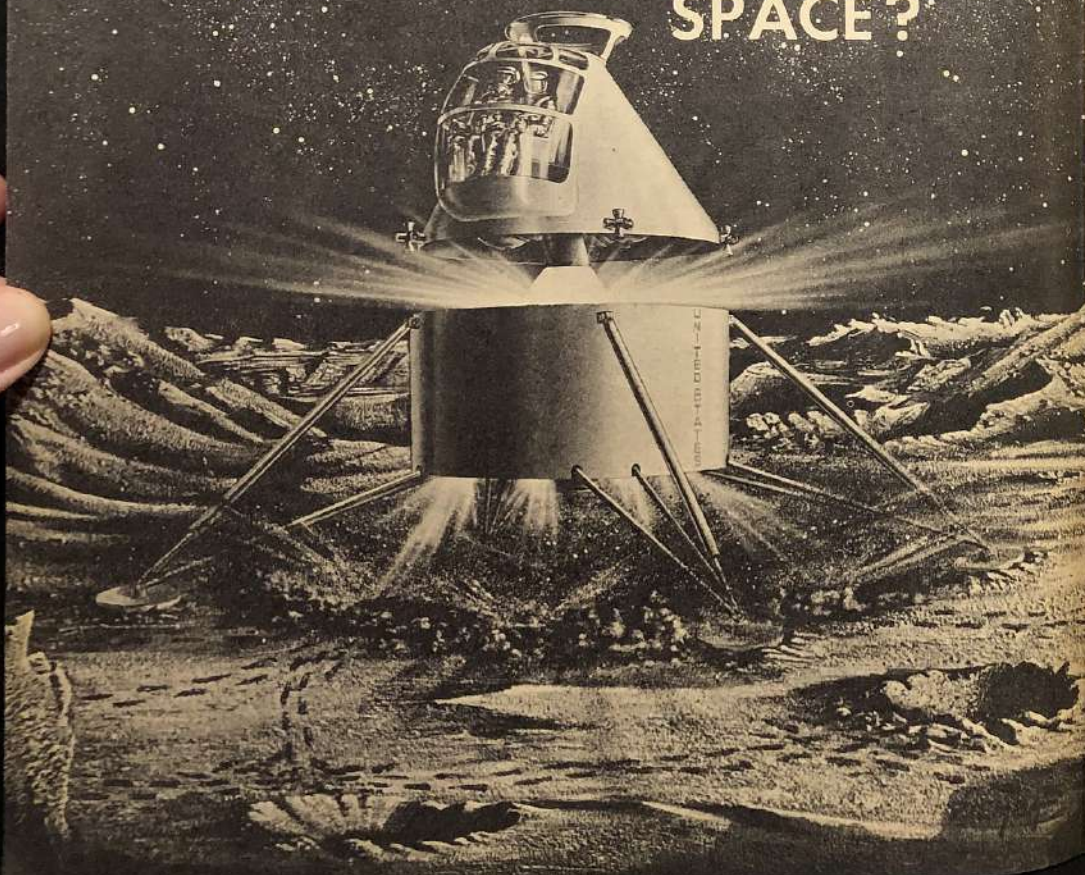
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SPACE SUITS

ALBUM: X-20 HOW IT FLIES



CAN MAN SURVIVE IN SPACE?



MEDICAL ASPECTS OF SPACE FLIGHT

by
Frank B. Voris, M.D.
NASA
Office of Advanced
Research and Technology



Before man can make prolonged trips into outer space many major space medicine problems facing us today must be solved. When we stop to think about it, we realize that for the first time we are now placing man into a hostile environment in which there is literally nothing to help support him. In submarines we may use water to good advantage; in high altitude jet aircraft we scoop up enough air to compress for man's use; in the Antarctic man is able to use much of the natural environment to exist. In space, however, only the energy of the sun is available for man and this only partially supplies the power he requires. He must take his gaseous atmospheres and pressures and his food, water, and energy supplies with him or perish.

Let us take a look at our most obvious problem, that of supplying man with his respiratory requirements. For Mercury and through Project Apollo, we plan to use pure oxygen at a pressure of five pounds per square inch. The Russians have used 14.7 pounds per square inch with approximately 20 per cent oxygen on all their flights. Although our 100 per cent oxygen systems have proven adequate, and hopefully they will continue to be so, I feel that for our advanced missions of over 14 days we will be required to go to a mixed gas system of more than five pounds per square inch. The reasoning behind this is

the result of research on oxygen toxicity, development of atelectasis in subjects on 100 per cent oxygen, and the results of studies in radiation effects on living tissue that is saturated with 100 per cent oxygen.

Because of restrictive weight penalties, we are required to reclaim all the unused oxygen from the astronauts expired breath. (Eds. note: The air we breathe is only one-fifth oxygen. Of this amount, only about one-fourth is absorbed by the blood. Furthermore, the hemoglobin gives up only about one-third of the oxygen it is carrying to the tissues.) At present, and for our future flights, the carbon dioxide and trace contaminants must be removed chemically from the expired oxygen prior to reuse by the astronaut. For more advanced systems this carbon dioxide will be broken down into carbon and oxygen. The carbon will be used for radiation shielding; and, of course, the oxygen will be used for the gaseous atmosphere.

The reclaimed water may also be hydrolyzed producing hydrogen which can then be combined with the carbon to produce methane, which can be further synthesized to form formaldehyde and finally various sugars. Again, the oxygen will be used for breathing. Thus, future vehicles and planetary bases will utilize each atom of material available, producing usable oxygen and edible sugars from the carbon di-

oxide and water produced by the body metabolism of man.

In using a mixed gas system, we must find an inert gas with a low diffusion factor that is non-toxic, light, easily obtained, handled, and stored. We are of some knowledge concerning the physiological effects of nitrogen; we know less about helium and very little of argon, neon, and other rare inert gases. It appears reasonable at this point to predict that nitrogen will be the inert gas of choice for our early extended flights. However, our ongoing research into these other gases may prove me wrong.

In order to protect the present day astronaut from the effects of losing his capsule pressures, we place him in a full pressure suit. Should his capsule be struck by a meteorite or in any manner lose its atmospheric integrity, the astronaut without his suit would be exposed to a vacuum. The dissolved gases within his blood and body tissue would immediately be released and he would suffer death within a very short period of time.

The full pressure suit is air impervious and fully encapsulates the man. When the capsule pressure drops below five pounds per square inch, the suit valve closes and air pressure within the suit supplies enough pressure to keep the man fully surrounded by five pounds of air pressure. The suit is a necessary safety device, but it is cum-

bersome when under pressure; and, under normal operating conditions, it requires a high ventilation flow of dry cool air to keep the astronaut from suffering from heat and his own sweat. Incidentally, the full pressure suit is a primary piece of fire-fighting equipment. In space the most expeditious and safest means of putting out a fire within the capsule is to open the capsule thus creating a vacuum within. Without oxygen the fire dies. The suit keeps the man at five pounds per square inch.

Here again, it is my personal opinion that we cannot keep our future astronauts in the present full pressure suit for prolonged periods of time. We are hard at work trying to devise methods of affording the astronauts the safety features of a full pressure suit with the comforts and facilities of a "shirt-sleeve" environment. This is no easy task.

Furthermore, future space operations require extra-vehicular maneuvering of men in free space as well as on lunar and planetary surfaces. Here the man will be required to work in varying degrees of a weightless state, and thus in reduced or frictionless environments. He will be subjected to extremes in temperatures, brilliant light or extreme darkness, and, of course, to radiation hazards. We must devise and provide adequate protective extravehicular suits for individual space men with reliable independent life support systems and self-maneuvering devices.

Another major area of concern to the space surgeon is that of acceleration. In order to withstand the acceleration forces required to boost a vehicle into orbital or escape speeds, we place man on his back facing the line of flight. Thus, the acceleration forces during the boost phase are exerted on him and his organs transversely from chest to back. Should he be in a seated position, the acceleration forces would act from his head to his buttocks. Hemostatic pressures would build up within the cardiovascular system that would prevent sufficient blood to reach the brain, thus causing unconsciousness. Prolonged ischemia can cause permanent cerebral damage. In a horizontal position the cardiovascular system becomes a horizontal pumping

system. Thus, the blood cannot pool in dependent organs and limbs. There is little build-up of hemodynamic pressures, and the heart has the capacity to pump blood into the brain. Thus, the period of useful consciousness is greatly extended during prolonged acceleration forces.

As you know, each astronaut has a custom made, form-fitting molded couch in his vehicle. By this fact, when acceleration forces increase the body weight, these excessive forces are distributed equally throughout nearly one-half his entire body surface. Thus, he can remain relatively comfortable through prolonged high G force phases of flight.

Another environmental factor of considerable concern that is receiving a great deal of scientific attention is weightlessness.

Once through the acceleration phase, the astronaut suddenly finds himself weightless. Under this condition nothing has weight. Thus, the blood within the blood vessels is as weightless as any other portion of the body or anything in the vehicle. Weightlessness is a phenomenon that is caused by the speed of the vehicle counteracting the gravity force of the earth. Thus, at a speed of 17,500 miles per hour, the vehicle will

rotate about the earth at approximately 100 miles altitude in a relatively fixed orbital path.

Theoretically, should the earth's gravitational pull suddenly cease, a speeding orbital vehicle would shoot away from the earth in a straight line tangential to the earth. To give you an idea of the delicate balance between the speed of the vehicle and the earth's gravitational pull, firing of the retrorockets slows the vehicle only about 350 miles per hour. This is enough, however, to allow the gravitational pull of the earth to take over, and the vehicle gradually descends toward the earth. Once the capsule begins to contact the atmosphere, the resistance to the speeding vehicle increases and the deceleration rate increases.

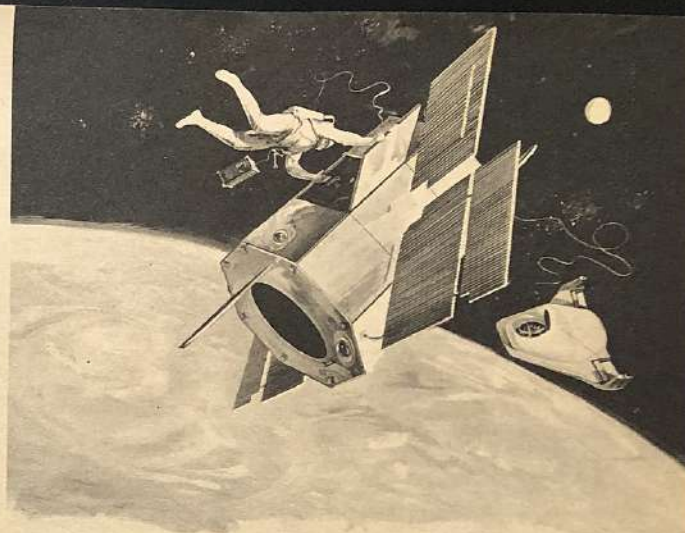
To date effects of weightlessness have not been detrimental to man in space. However, we have reason to believe that over longer periods of time weightlessness may take its toll in producing adverse physiological effects. Most of us are well aware of the reaction of well and healthy individuals who have been restricted to absolute bed rest for prolonged periods of time. First, upon rising they become faint, developing varying degrees of syncope symptoms from blanching to loss

of consciousness. Secondly, should they be kept up on their feet, they develop dependent edema or swelling of the feet and ankles. (Both Schirra and Cooper developed these symptoms.) The same effect has been noted in subjects who have been fully submerged in water during studies of neutral buoyancy. The cardiac action and capacity has changed and cannot react quickly to the changes in the hemodynamics of the changed position of the body. Secondly, the characteristics of the peripheral vascular system have changed. The arteries and veins of the lower portions of the body do not accommodate the blood, and the tissues become edematous. The kidney function is altered with noticeable increase in urine output.

A very serious effect of prolonged bed rest and neutral buoyancy is that of a shift in the body metabolite balance. The major shift is a marked increase in blood calcium which is subsequently excreted by the kidneys. This increase is due to a rather early and definite demineralization of the bone. This factor has been noted in our checking of the astronauts after Project Mercury flights. I do not know the mechanisms that cause these physiological changes in the basic functions of the body. We have no idea how far the cardiovascular system adapts to the dynamics of weightlessness or how great demineralization becomes before the process slows or stops if in fact it does stop.

With the thought that bed rest without exercise caused the aforementioned changes, the experimenters had one-half the subjects do vigorous exercises while remaining flat on their backs. The exercise worked wonders for the muscular system, but the results on the cardiovascular system and the metabolic processes were the same as for those who did no exercising.

What can this mean to the astronaut should these changes progress over several weeks or months of weightlessness? First, the cardiovascular system and the bony structure of the body may fail upon being subjected to the relatively prolonged and high acceleration forces experienced during reentry. Loss of consciousness, myocardial insufficiency, or complete cardiac



Can a satellite be repaired in orbit? It is possible that in orbit repair will one day prove to be more economical than second launches and the replacement of whole satellite systems.

failure may result. Fractures may result from the loss of adequate bone structure. We may well be required to place a successfully returned astronaut in a rehabilitation center where he will gradually regain bodily activity and learn to walk again. The one-gravity field we know and react to so well here on earth will be strange to the astronaut.

A third major hazard to which we have turned considerable attention is that of radiation. The effects of certain radiations are well known to us. We have developed equipment to produce a variety of radiation energies and particles and have exposed biological specimens to these hazards. However, we still know very little of the biological effects of mixed radiation energies and the extent of effects due to secondary energies received by occupants in spacecraft. Much more work must be done to develop better passive and active shielding systems for future flights.

During Projects Mercury, Gemini, and early Apollo flights very little, if any, radiation hazards have been or will be encountered. We are interested in the heavy primary strikes from galactic sources; but as these flights are not scheduled to meet the Van Allen Belt concentrations, there is little concern for

the astronaut. The later Apollo flights will be required to pass through the earth's geomagnetic fields and into outer space where the full energies of the sun and its solar flares will be met. We have not been successful in fully mapping this space for its radiation hazards nor have we accurately defined the concentrations and variety of the mixed radiation energies to be met.

Additional hazards will result when men leave the protective shell of the vehicle for extravehicular work in free space or on the lunar surface. Added biological effects of radiation exposure may result from using 100 per cent oxygen during these extravehicular operations.

Future plans call for active shielding systems that may well place a man in a vehicle that is surrounded by a strong electromagnetic field that will repel or trap the particles much as our own earth's geomagnetic fields do. What effects these high-magnetic fields have on man is still unknown. Another facet of study concerning electromagnetic fields involves the biological effects of null or low field forces and, of course, effects on living tissue passing through varying magnetic field forces. We are extensively studying animals and men in altered magnetic fields and hope to have very definite answers

Man faces many problems on the surface of another planet. Communications is only one of these problems.



in the near future.

We don't usually concern ourselves over food here on earth. Of course, there is the inevitable indecision of selection from a generous menu; but, little thought is given to nutrition by the average person. The problem of feeding in submarines and aircraft, on hiking and camping trips, and even in the polar regions can easily be solved. This is not so in space.

First, restrictive weight penalties force a new technology upon us, that of perfecting nutritionally ideal foods. Secondly, new methods of packaging and preserving foods must be developed. Next, weightlessness requires us to establish an entirely new dietary regime, from controlling the amounts and consistency of foods consumed, to the actual methods of eating. Finally, the fundamental metabolic requirements of individuals must be defined and functionally stable diets calculated to meet those requirements.

Throughout Project Mercury and during our early Gemini flights, diets will be much as we recognize them. Known foods, some changed in consistency so as to be packaged into tooth-paste tube-like containers, others made into bite-size biscuits, are available and used. Water, soups, juices, etc., in closed squeeze-bottle containers are adequate for fluid requirements. This is essentially like taking along a picnic lunch. The longer duration Gemini and Apollo flights will have aboard many natural foods that have been dehydrated by quick freeze drying techniques and that can be quickly reconstituted into palatable life-like foods by merely adding specific amounts of water. Presently, these foods are being fed to subjects in our isolation and confinement studies.

In the advanced manned space flight missions beyond Project Apollo, we will be required to abandon our normal concept of food and idealize our nutritional intakes for the space traveler. We are at present using basic amino acids, metabolites, and vitamins in detailed studies of fundamental metabolic requirements of men under varied conditions. Metabolic requirement profiles are being established for individuals. In this manner, precise diets can be defined for each

crewman. It may well be that a slurry of amino acids, metabolites, and vitamins will be mixed for each meal that will produce an optimum metabolic balanced intake for man and also present the least payload penalty. Beyond this, production of foods in space and for permanent lunar and planetary bases is an active area of research.

As I mentioned before, we have already produced sugars from man's expired carbon dioxide. I actually have a vial of this "space sugar" in my office in Washington. Much has been done to develop methods of producing food from algae harvested from biological closed ecological systems. Here the algae uses man's waste materials, carbon dioxide, and light to produce oxygen through cellular reproduction. The reproduction and growth factors of many animals and plants are currently being studied in order to determine methods of producing a more favorable edible-nonedible ratio in plant and animal production.

I for one feel that man will require more than an idealized slurry to live and proficiently function. For morale purposes alone I feel we must, at least occasionally, feed the space traveler a meal that he is accustomed to eating here on earth. A good "Sunday dinner," so to speak, will keep the astronaut in touch with reality.

An associated problem is one of the collection and disposition of bodily wastes. Foods will be packaged so that the containers are edible with no resultant garbage or container problems, but man's excreta is not so easily managed. The urine or feces must be collected under weightless conditions. This requires a closed collection system. These wastes must then be processed to recover all the water for future use. The remaining solids are to be further processed into basic chemicals for the production of food, power, or shielding. The United States has committed itself to a policy of not contaminating outer space and the lunar and planetary surfaces until such time as our basic scientists have completed a reasonably exhaustive study of those areas. This requires a complete decontamination of our vehicles and the external surfaces of our extra-

vehicular suits, and a containment or complete sterilization of all contaminating excreta should we be required to jettison our waste materials during these early flights.

Mechanical ingenuity is taxed to the utmost when trying to devise a fecal collection device for a single astronaut that will function practically and esthetically while he is strapped in a molded couch within a very limited space capsule wearing a form-fitting full pressure suit with a minimum of apertures to reduce leakage, while in a weightless state. All presently planned waste collection systems are required to be closed and work under low vacuums to create a flow of liquid and air away from the body excretory organs.

As you know, it is planned that men will leave the protection of their vehicles and explore free space and lunar and planetary surfaces. I have mentioned the development of extravehicular suits and the protection required against radiation, extreme temperatures, the lack of atmosphere, and other environmental hazards.

One very serious problem that is seldom mentioned is that of being struck by a micrometeorite. These bits of material fly through space at fantastic speeds up to 60,000 feet per second. In outer space and on the lunar surface, where no atmosphere exists, these particles strike with uninhabited speeds. Should an astronaut be struck by one and penetration occur, the heat of impact alone will ignite the 100 per cent oxygen that is under five pounds per square inch pressure within the extravehicular suit. Flash explosion would completely burn the occupant.

Impacts of high speed meteorites striking the lunar surface send showers of secondary fragments of the moon's crust that travel at speeds only slightly less than that of the primary meteorite. With a gravity force of only one-sixth of that of the earth and with no atmosphere, these missiles travel great distances with forces well above that required to penetrate present-day full pressure suits. I feel we must provide an armored device to protect extravehicular operators from the greater percentage of these chance micrometeorite

strikes.

Lastly, I would like to discuss the psychological aspects of the selection and training of astronauts and of space travel.

We have extensive research programs in all aspects of space psychology. Animal and human subjects are studied for the effects of isolation, confinement, and sensory de-

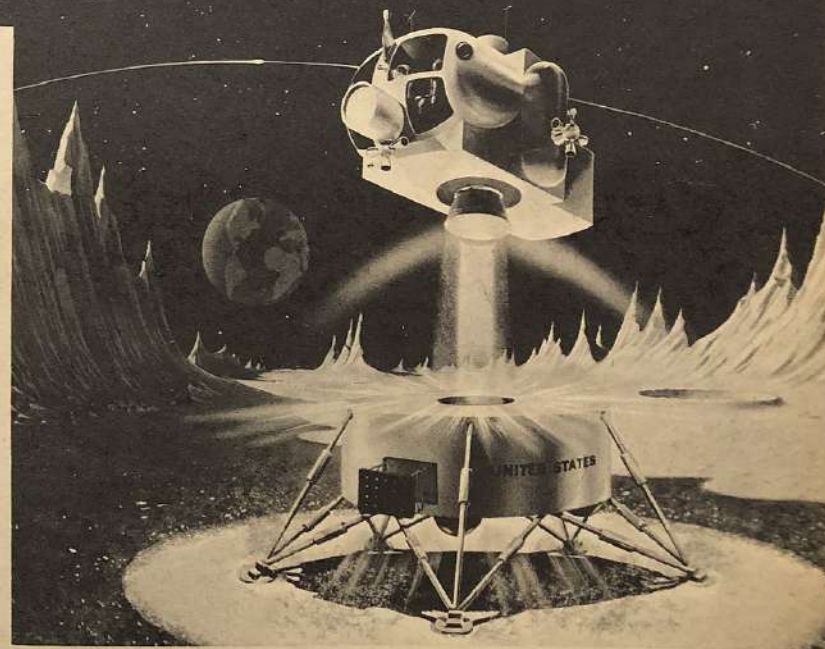
privation. Men have spent months in isolation undergoing performance testing while being subjected to many of the stresses found in space travel. During these periods the subjects are observed psycho-physiologically and are biochemically assayed. Subjects have been individually isolated and joined in crews for inter-

action observation and performance tests.

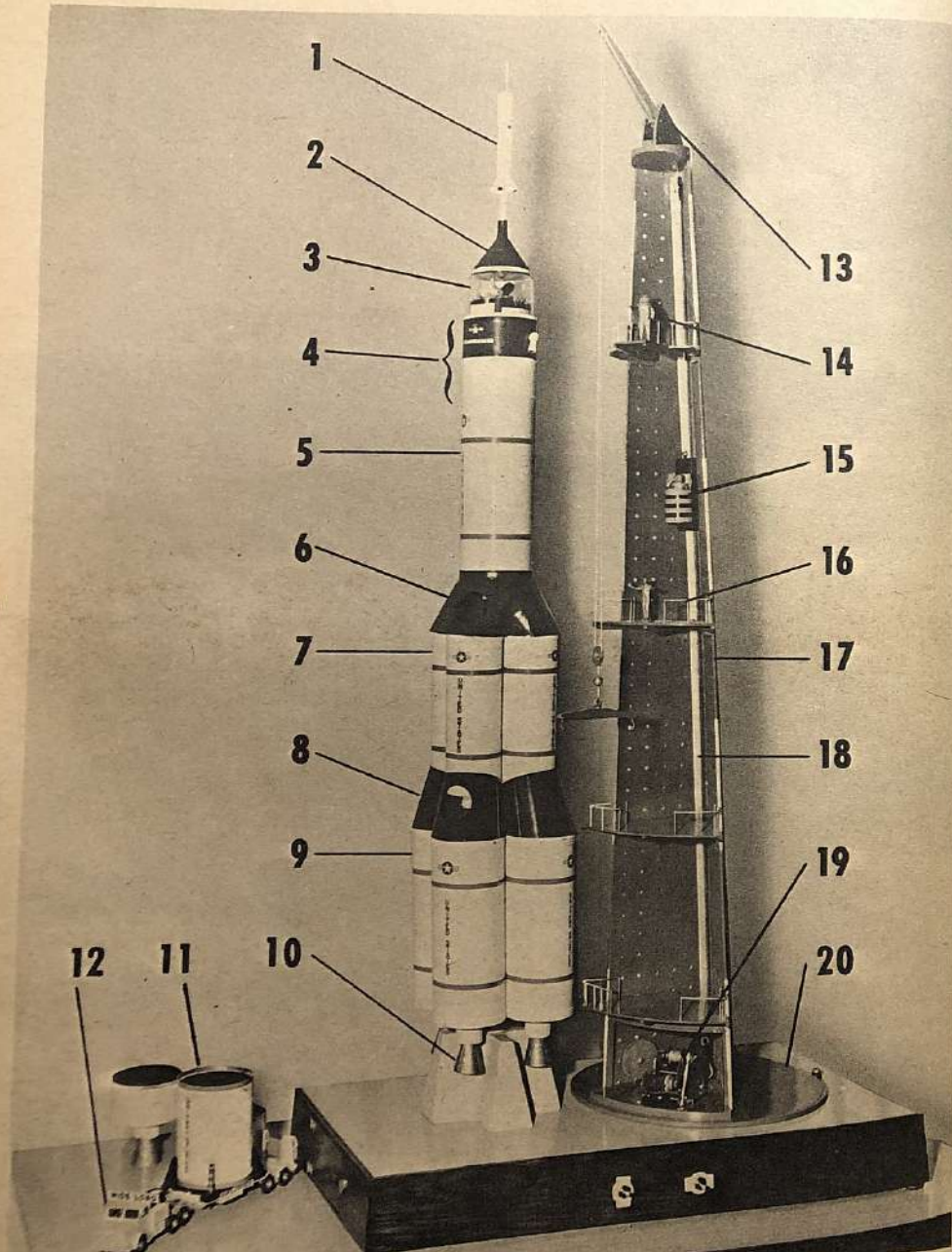
These studies will result in finer selection criteria and more definitive training programs. It will help us to assign crew responsibility, predict and obviate performance failures, and regulate work-rest-sleep cycles to best advantage.



Artist's concept of the nation's first nuclear-propelled space vehicle in flight.



Powering the Lunar Excursion Module (LEM) from the surface of the moon.



Do-it-Yourself

SPACE LAUNCH VEHICLE

When America's moonmen go on their lunar Apollo mission later this decade, they'll be on a low starch diet. But if they were to travel the Orville Dart way, starch would play an important role in their trip.

For Dart, Lockheed Propulsion Company's resourceful standards laboratory technician who earlier this year built a model rocket motor out of coffee cans, now has created a replica of a three-stage, segmented solid propellant space launch vehicle. All the rocket motors - nine of them - are made from plastic laundry starch bottles.

Dart's company, selected by the Air Force Space Systems Division to design, build and test-fire two 13-foot-diameter segmented solid propellant motors early next year, calls the feasibility demonstration program the LSM, for Large Solid Motor.

Dart calls his new model the LES, for Large Economy Size. Big quart-size starch bottles are used to simulate 156-inch-diameter rocket motors in the first and third stages. Pint-size bottles represent a cluster of four 120-inch motors in the second stage.

Now he won't give two beans for his earlier coffee-can model of a 10-foot-diameter applied research

motor in its test bay - the full-scale original was fired by Lockheed under contract to AFSSD. Dart says coffee cans are dated.

In the aerospace industry, engineers refer to components which are already in existence and do not require special design or scientific advances as "off the shelf" items.

Dart's components are really off the shelf. The market shelf, that is. They include juice cans, funnels, tuna cans, plastic cole slaw containers, plastic pencil sharpeners, construction spacers, aluminum tubing, miscellaneous nuts, bolts, washers and springs. Ten dollars and 200 hours went into building the model.

First stage clusters four of the starch bottle "156-inch" motors. They are what is technically called one-segment motors, which means that they are actually made in three pieces - forward, center, and aft segments. Additional center segments can be added to increase the rocket's boost power. Second stage is a cluster of four "120-inch" motors; third stage is a single "156."

Atop this is a two-man spacecraft, and crowning the whole thing is a launch escape rocket made from a construction spacer. The whole structure stands about four feet high.

An actual lunar rocket based on these elements would be more than 30 feet wide at the base and more than 300 feet high.

The accompanying four-level gantry has an electric-powered crane and elevator. In addition, Dart provided unmanned "156-inch" forward, aft, and center segments and a truck to transport them.

Lockheed's propulsion experts are taking a lively interest in the model, as it gives them a three-dimensional demonstration aid in projecting space missions for giant solid propellant rockets.

They question whether the rocket, as assembled, could provide sufficient power to send the manned spacecraft and necessary supporting units on a lunar mission. But they point out that the mission could easily be accomplished by adding to the length of the versatile segmented solid motors.

Slide rules are in play as they calculate how many additional segments must be added to orbit a space station or to send a spaceship to Mars.

Dart, the father of the LES, is keeping mum about follow-on missions beyond his two-man flight.

"My immediate assignment from Headquarters," he said, "is to use up 10 quarts of starch."

From top to bottom, components (numbered) and their materials are: 1. Launch escape system (solid propellant) - 1 construction spacer; 2. Spacecraft exit fairing - 110-cent funnel; 3. Command module - 1 plastic cole slaw container; 4. Service and lunar excursion modules - 2 tuna cans; 5. Third stage, 13-foot diameter segmented solid - 1 quart-size plastic liquid starch container; 6. Third-stage - second-stage adapter - 1 35-cent funnel; 7. Second stage, cluster of four 10-foot-diameter segmented solid propellant motors - four pint-size liquid starch containers; 8. Second-stage - first-stage adapters - four frozen juice cans; 9. First stage, four 13-foot clustered solid propellant motors -

4 1-quart liquid starch containers; 10. Rocket nozzles, nine in all - plastic "mercury Spacecraft" pencil sharpeners; 11. Motor center segment solid propellant grain - styrofoam shaped and painted black; 12. Truck transport and motor cradle - truck, purchased and painted masonite; 13. Crane boom and support - wood and masonite; 14. Extra astronaut - toy figure; 15. Elevator - 1-inch aluminum tubing; 16. Safety railing - welded wire fencing; 17. Gantry tower - peg-board; 18. Elevator track - wood; 19. Turntable and electric elevator driver, battery generated - toy motors and various gears and washers found in home workshop; 20. Turntable and cabinet base - quarter-inch plywood.

An added advantage which distinctly favors MHD control or heat transfer reduction is that the magnet used for control already may be on board to shield occupants from dangerous charged particle radiation. This hazard may come from such sources as solar flares or the Van Allen radiation belts.

Our own planet earth demonstrates on a grand scale that a magnetic field can deflect an oncoming stream of charged particles. Streams of electrons and protons from the sun (the solar wind) sweep toward earth, where our magnetic fields divert them around the earth at distances of about 40,000 miles. An on-board magnet can achieve a similar deflection.

Another MHD application, space propulsion, should become a reality within the next few years. The chemical rocket produces high thrust for lifting a vehicle away from the immediate vicinity of earth. But once the vehicle is out in space, the MHD (plasma) engine appears to be a more favorable method of propulsion. The high specific impulse (thrust divided by rate of propellant consumption) of an electromagnetic propulsor makes it superior for extended flights, where propellant economy is the governing factor.

The variety of MHD and plasma engines is almost unlimited. The simplest classification is into two groups, one characterized by continuous operation, the other by pulsed operation. In the first group, a jet of plasma issues rather steadily from the propulsor. In the second, plasma is emitted in discrete blobs. Another classification compares MHD propulsors to ordinary electric motors, defining them as series (the Bostick button gun), shunt (the crossed-field propulsor), and induction (the traveling wave accelerator) types.

You can also use MHD principles to generate electric power on the ground. These generators are potentially more efficient than today's generators because they are not limited by the ideal thermodynamic (Carnot) efficiencies and because they do away with the need for intermediate equipment, such as steam generators and turbines. In the simplest scheme, hot ionized gas is forced through a magnetic

field, generating an EMF (electromotive force) at right angles to both the gas flow and the magnetic field. This electric potential produces current flow in an exterior circuit.

This has been a brief review of some purposes and useful aspects of magnetohydrodynamics and plasma physics. But what of the supporting research and, in particular, Grumman's increasing theoretical and experimental efforts in exploring these phenomena?

In our Plasma Physics Laboratory we are investigating the properties of moving plasma - specifically, we are determining the principles governing the generation, acceleration, guiding, and bending of the plasma.

Laboratory mechanisms can create several types of plasma. One device Grumman uses is a puffer valve. It puffs a controlled amount of gas into an evacuated chamber or tube where electromagnetic radiation ionizes it. Upon ionization, a rapidly varying magnetic field accelerates the plasma to the order of 1/1000th of the speed of light. Other fields confine and bend the plasma after acceleration. Through investigations of the principles governing plasma action, we will gain knowledge for designing improved space vehicle propulsors, simulating the environment of outer space, and producing hydromagnetic shocks.

We have been examining hydromagnetic shock waves from a theoretical standpoint for several years. Visualize these waves as a current sheath separating regions of different density and pressure. They are the counterparts of such aerodynamic shock waves as are involved in the familiar sonic boom. Small amplitude MHD shocks, generally called "whistlers", have been detected traveling high above the earth's atmosphere.

A form of hydromagnetic shock can occur when a vehicle re-enters an atmosphere at extreme speeds. It's important we understand these phenomena more fully because they constitute real problems basic to the study of electrically conducting flows through magnetic fields.

The Research Department also is experimentally attacking the problem of MHD turbulence, an extension of common fluid turbulence,

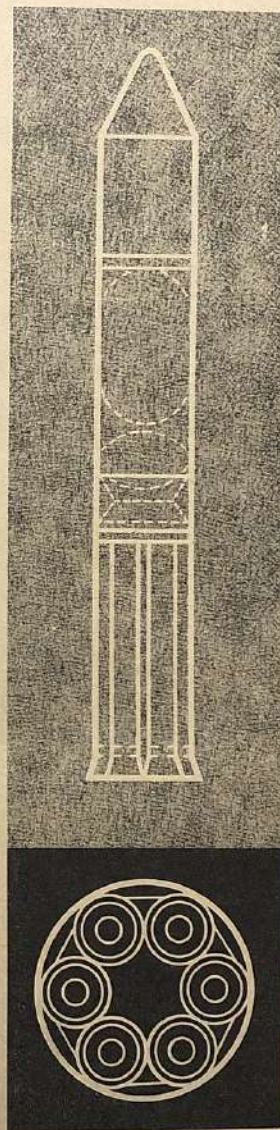
This is of great interest because it occurs in varying degrees in practically all magnetohydrodynamic devices. To implement this program, Grumman has acquired a 41-ton, iron-core electromagnet which can generate a 20,000-gauss magnetic field in a four-cubic-foot volume. This is 40,000 times stronger than the earth's field. The conducting medium for the turbulence investigation will be liquid mercury.

Grumman scientists have probed the feasibility of MHD control as part of an investigation for the Air Force. They sought to determine the magnitude of the interaction of forces occurring between the ionized gas surrounding a hypersonic vehicle and a magnetic field.

The latter research study at Grumman has been predominantly theoretical, although experimental work has been carried out in the Research Department's Hypersonic Shock Tunnel. Already, the theoretical studies have indicated several interesting possibilities for this type of nose control. The order-of-magnitude analysis determined the altitude-velocity regimes where appreciable electromagnetic forces are developed.

Preliminary results indicate that MHD flight control is most effective at superorbital velocities and at altitudes not higher than 50-60 miles, using strong magnetic fields and large nose dimensions. Initial experiments attempted to magnetically displace the shock wave in front of a hypersonic model. These experiments, the first of their kind to be tried in a shock tunnel, have not been conclusive, so far. If we succeed, we will seek experimental verification of the theoretical analysis.

Attempts to harness the Lorentz force are not without difficulties. A big problem in space flight propulsion and control is development of lightweight electric power supplies and circuit components. Difficulties in getting significant gas conductivities and powerful magnetic fields severely limit the useful range of operation. We may have to develop "seeding" techniques to raise electrical conductivity values in certain flight regimes. This may be done by introducing small quantities of easily ionizable substances into the flow.



MILLION POUNDS IN ORBIT

By KENNETH CALKINS

A NOVA-CLASS launch vehicle proposed by a recent Boeing study would stand about 380 feet high on the launching pad, with its payload rising above that. This is considerably taller than the highest peak of land in all Florida.

The booster, with a cluster of 260-inch solid-propellant motors for its first stage and five liquid-hydrogen rockets in its second stage, would be bigger than many an office building. This chunk of metals, ceramics, plastics and fuels most certainly would be man's biggest export into space—until something larger came along.

Objective of this particular study was a vehicle design based on current technology, but with payload capability of 1,000,000 pounds—much larger than the 200,000-pound capacity of Saturn V. The Nova vehicles could be used to support manned planetary expeditions, manned lunar bases and other equally ambitious missions of the future.

The work just completed—an extension of earlier Boeing studies of solid-booster vehicles—was done under contract for the Marshall Space Flight Center of the National Aeronautics and Space Administration. Further studies of vehicles in this class are under way by the Boeing Aero-Space Division at Seattle.

George Van Winkle, Nova study project engineer for Boeing, notes that "A vehicle designed for later time periods could incorporate tech-

nical advances not now available, and allow the same performance with a smaller vehicle."

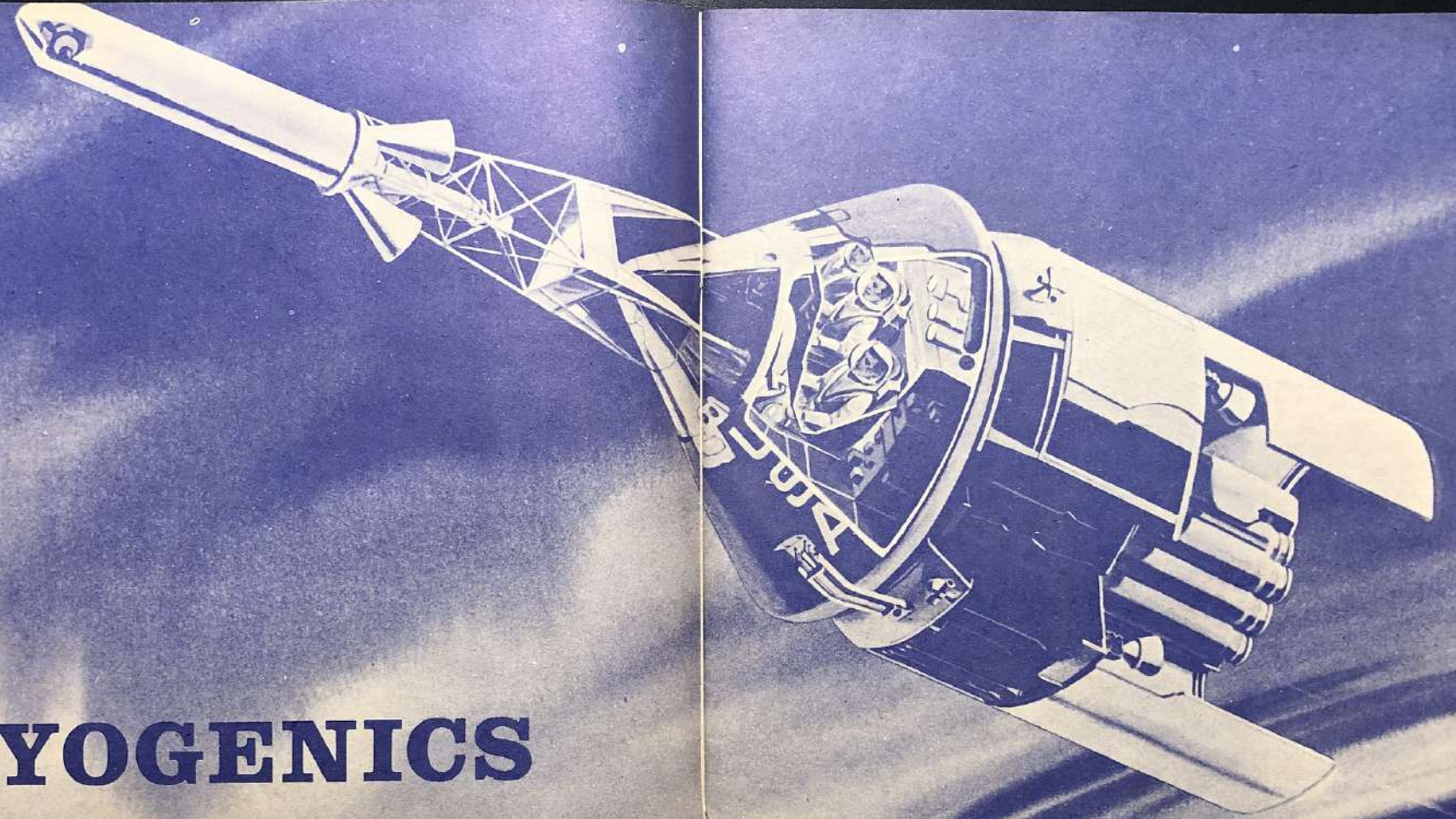
Earlier Boeing studies of boosters involved segmented rockets—thick slices of solid rocket fuel stacked one on the other like poker chips. The million-pounds-in-orbit booster will not involve segmented motors.

"Slicing up the booster had one purpose: to make it easier to move overland," said Van Winkle. "Segments are lighter to handle than whole boosters—even segments 156 inches in diameter. But when they get to be 260 inches in diameter, hauling them overland is out of the question."

A booster as large as the one studied by Boeing would have to be barged to the launching pad, according to Van Winkle. Segmenting offers no advantage when using water transportation.

Nor would the Boeing booster studied under this NASA contract be recoverable. There is no economic advantage at this time in bringing back the empty shell of a solid-fueled rocket, according to Van Winkle. The cost of manufacturing solid motor hardware is relatively low as compared to propellant costs.

The same is not true of liquid-fueled boosters. The cost of liquid fuels is low—between 15 and 20 cents a pound. But the cost of the tanks, engines, valves, pipes and other hardware used to control and contain those liquids is high. It would be worthwhile to recover the liquid-fuel boosters after burnout.



CRYOGENICS

**...products for
the realm of
supercold**

Garrett's environmental control system for Project Apollo, NASA's three-man, two-week space vehicle, will require atmospheric gases (oxygen and nitrogen) that are carried compactly as cryogenic fluids. North American Aviation is the prime contractor.

What most people think of when they hear the word "cold," may be the musical clinking of ice cubes in a glass. Or, providing they live in neither Phoenix or Los Angeles, it may provoke the memory of mountainous drifts of snow from the winter just past.

But the coldest day ever recorded was only 100 degrees F below zero—in the antarctic. This is not exactly warm, but compared to the world of the scientists and engineers who deal with cryogenic temperatures, it is pretty mild.

Cryogenics is the realm of supercold. And from this region is coming an exciting new technology giving birth to whole new types of military and scientific devices, and important advances in physical theory.

The range of temperature that is termed cryogenic begins at about minus 200 degrees F and descends to absolute zero or minus 459.7 degrees F.

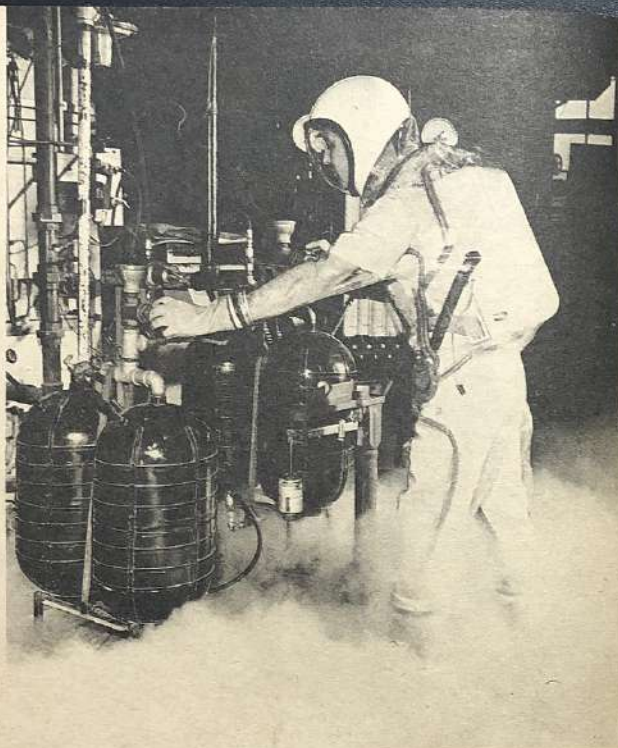
In the past 10 years, what goes on physically at these temperatures has grown from a purely scientific interest to a practical and diversified technology.

What makes these low temperatures so interesting hinges around this fact—below about 200 degrees F the electrical resistance of certain metals and alloys disappears completely. This phenomenon, called "superconductivity," means that revolutionary devices for military, commercial and space use can, and are, being built.

In military applications, a cryogenic infrared detector system cannot only discriminate between types of aircraft, it might even track a ship across the ocean by sensing the minute temperature change made by passage of the ship through water.

For computers, tiny electronic switching devices called cryotrons have been developed whose switching time is so short it has never been successfully measured. Used in computer memory circuits and switches, they not only greatly speed up the operation of the computer, but a roomful of equipment can be reduced down to occupy a few square yards. They are also exceptionally inexpensive to produce.

Superconductive electromagnets are now being built for research work that will have tremendous



Garrett cryogenic "back packs" are being produced for missile fuel handling and ground support uses.

power and take only a fraction of the area now needed by noncryogenic units.

In communications, since the earliest days of radio there has been an effort to produce higher frequency, shorter length radio waves which can transmit more information. Wave amplification devices, such as the maser, use cryogenic cooling.

Optical masers (lasers), amplifying light instead of radio waves, may be used in communications from earth to satellites or space vehicles. The light developed is very directional. A beam four inches wide sent from earth would spread to a width of only several miles on the moon, an extremely small divergence in light.

Work is also being pushed on the development of very powerful optical masers which can be used as weapons. Emitting a beam of high intensity radiation, these weapons operate almost like the science fiction

"death ray," and may eventually be the solution to destroying enemy missiles in flight.

Garrett's AiResearch divisions are establishing themselves as leaders in their own particular aspects of cryogenics. Garrett is, in fact, a relative "old timer" having been in cryogenic research and development work since the mid 1950's.

At AiResearch Los Angeles, work is being conducted on cryogenic refrigeration systems, environmental controls systems and storage systems. AiResearch Phoenix division is working on products such as valves and control systems for handling and controlling cryogenic fluids.

Cryogenic temperatures are achieved by liquefying various gases which have extremely low boiling points; gases such as oxygen, nitrogen, neon, hydrogen and helium. Since at room temperature these gases have long since boiled off and vaporized, they were thought a

century or so ago to be "permanent" gases. For example, where water boils at 212 degrees F, helium boils at minus 452 degrees F.

To produce the cooling needed for operation of the types of equipment mentioned earlier, AiResearch is developing and producing two types of cryogenic refrigerators; open cycle and closed cycle.

line and the necessary stop, start and flow controls. While this may sound like relatively simple equipment, some significant problems had to be overcome before a workable system resulted. For here little was known about dealing with cryogenic fluids, the behavior of metals at low temperature or insulating materials. AiResearch engineers were

ogenic liquid. A small diameter tube of flexible silicone rubber is used. It has no special insulating qualities. It is not especially cold to touch, yet through it liquid nitrogen can be delivered without critical vaporizing for distances up to 25 feet. The secret is in the manner of controlling the flow.

The open cycle type of system has application where the period of cooling is not long and the cryogenic fluid is easily available. It is especially suitable aboard an aircraft, where it can cool infrared detectors or other types of communication or detection equipment.

Recently AiResearch was the first designer and manufacturer to achieve large scale production of open cycle cryogenic systems. These AiResearch units now fly aboard the McDonnell F4H.

Put an open cycle liquid air system on a man's back, clothe him in some kind of protective suit, and you have a self-contained environment for dangerous jobs like handling toxic missile fuels, or fire-fighting and rescue work.

An AiResearch open cycle oxygen unit designed for cooling pilot pressure suits found an application beyond aircraft pilots not long ago. Astronaut John Glenn had carried an AiResearch unit connected to his suit while he traveled to and from his Friendship 7 Mercury capsule launching site. These cryogenic systems, such as the pilot suit cooling unit, are ready to operate within a few minutes if required, and need no outside source of power.

The AiResearch environmental control system for his capsule was not a cryogenic system, however. Because of the short duration of the mission, oxygen was stored as a high pressure gas.

When the refrigeration unit must operate for a longer time, or where the refrigeration system supplies cannot be maintained almost daily, the open cycle system is not feasible.

But to develop a closed cycle system which would operate reliably for a long time, particularly on the near-miniature scale required for aerospace use, was a task of tremendous proportions. And the key to this task was the development of a piece of machinery about twice the size of a roll of quarters. Inside it, turbine wheels would be spinning



Astronaut John Glenn carried a Garrett cryogenic suit cooling unit on his way to Mercury launching pad.

The purpose of both of these systems is to deliver a cryogenic liquid refrigerant to the point of use. In the open cycle system no attempt is made to keep and reuse the gas once it has been boiled and vaporized by absorbing heat. The closed cycle system does recycle the vaporized gas, condensing and cooling it back to a liquid form for continuous use.

The open cycle system consists of a storage vessel, liquid transfer

pushing the state of the art.

The storage vessel is a type of super thermos bottle. An outer bottle houses an inner bottle, which contains the cryogenic liquid. It is almost perfectly insulated to maintain the liquid state of the gas within. Contained between the walls of the two bottles is a high vacuum, sometimes including superinsulating material.

A unique element in this system is the manner of delivering the cry-

at several hundred thousand revolutions per minute.

A refrigeration cycle runs something like this: Compress a gas, such as air, at room temperature and it becomes hot. Take away the heat of compression without lowering the pressure and it cools. Let the gas expand back to its original pressure and it becomes cooler than room temperature - a refrigerated gas.

Most of the small cryogenic refrigerators under development when AiResearch engineers began working on a closed cycle system used piston machinery to compress the gas first, then later in the refrigeration cycle, to expand it. But piston-type machinery, when made very small and given the requirement to run a long time without trouble, develops serious problems.

The most difficult problem to overcome with any kind of cryogenic refrigerator is contamination. Piston systems usually operate at high pressure, and at high pressure the freezing out of impurities is accelerated. This happens to im-

achinery causes wear; a problem that is further complicated because oil-type lubricants cannot be used at these extreme low temperatures. In the tiny piston expander, where flow volume is already low, the smallest change in volume radically changes the performance of the system.

Normal leakage past pistons and valves, increased by wear, becomes almost impossible to control.

To AiResearch, with unequaled knowledge in small, high speed turbomachinery, the solution pointed to getting rid of the piston expander in the refrigeration cycle, the most critical part of the system. To take its place a miniature turbo-expander was designed.

A turboexpander is quite similar to a device called a cooling turbine. Cooling turbines, many times larger, have been standard equipment for more than 15 years in AiResearch aircraft environmental systems. They cool first by using the gas to spin the turbine wheel - thus extracting energy (heat) from the gas stream - then cool further

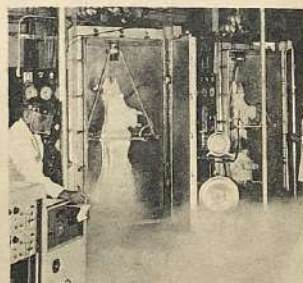
expander has been tested up to 350,000 rpm. The production unit operates at about half that speed.

The successful development of the turboexpander means many important advantages.

There is no wear in the turboexpander because there is no contact between moving parts. Instead of using conventional means of lubricating, AiResearch has advanced the technique of "air bearings," in which the rotating parts of the turboexpander float along on a cushion of the refrigerant gas. In addition, since lubricants are not needed, the major source of contaminants is removed.

The turbomachinery approach, also results in a refrigeration system that is significantly smaller in size. This is an important factor in most applications.

AiResearch took the step of tur-



Cryogenic fuel and oxidizer system for Atlas undergo shock and vibration tests at AiResearch, Phoenix.

Cryogenic heat exchanger for Dyna-Soar is being developed at AiResearch, Los Angeles.



Inner shell of supercritical storage system contains cryogenic fluid. Between the outer and inner shells are a high vacuum and superinsulating material.

purities in the cryogenic fluid, itself, but particularly with the lubricants needed by piston machinery. Within a short time contaminants build up in critical areas, affecting performance seriously and eventually clogging the system.

Secondly, the constant contact of the moving parts in piston ma-

by expanding the gas.

The AiResearch turboexpander for closed cycle cryogenic cooling is the smallest ever built. The turbine impeller wheel, one of two wheels in the turboexpander, is smaller than a dime - only four-tenths of an inch in diameter.

A prototype model of the turbo-

bomachinery for another major reason - the higher inherent reliability of turbomachinery over piston machinery.

The aircraft world was somewhat startled several years ago when an airline released its first figures on engine life comparison between jet and piston engines. As highly developed as the aircraft piston engines were, the first jets were giving 12 times as long in service before overhauls.

The closed cycle type of cryogenic system will have a large place in the growing market of cryogenic applications. But just as important, it is a major step in the direction of long life, maintenance free, miniaturized refrigerators for spacecraft.

There are other types of applications for cryogenic systems in space which are being developed now at AiResearch.

A complete environmental controls system, such as AiResearch is now providing for the three-man two-week Apollo spacecraft, is a highly integrated network of heat exchangers, air movers, controls and chemical agents which keep the temperature, pressure, humidity and gas composition at comfortable levels for the crew.

A system like this must carry its gas supply - oxygen and nitrogen - as cryogenic liquids, as it is the most compact method. Carrying them as a high pressure gas is not practical for missions lasting much more than 24 hours. In addition, fuel cells, and power supply systems which may use hydrogen, must carry their supplies as cryogenic liquids.

Of great interest to the designer of space systems is the fact that his equipment must operate in a condition of weightlessness or zero gravity. On earth a liquid settles to the bottom of a container and can be measured for volume and drawn off without difficulty.

But in space there is no up or down, heavy or light; liquid and gas pockets intermingle freely so that some means must be devised to make sure that gas and liquid do not come out alternately, and that the quantity of liquid remaining in the storage containers can be accurately measured.

AiResearch has been investigating zero gravity systems for several years, and in fact delivered one of the earliest systems to the X-15.

The most straightforward approach to solving the zero G problem is one called supercritical pressure

storage. Supercritical pressure refers to the point, in this system, at which the two phase fluid (a liquid and a gas) becomes one phase (a gas).

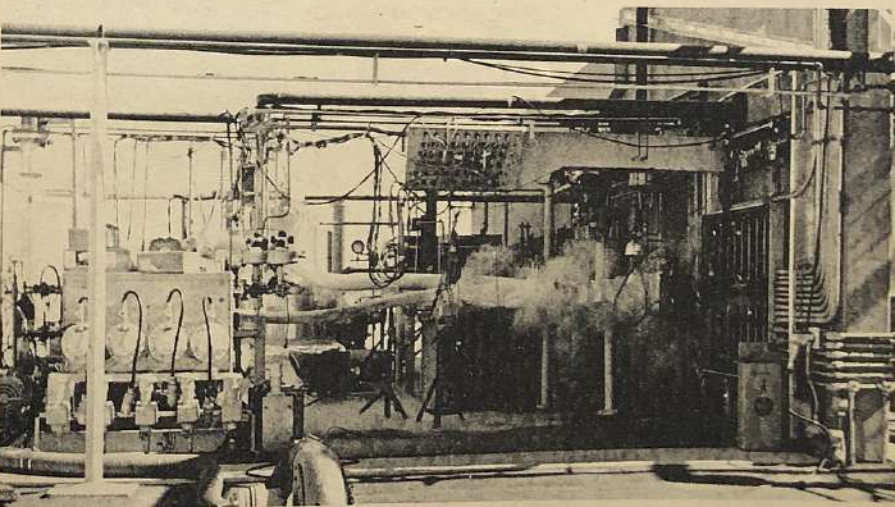
By carefully controlling the pressure and temperature within the storage vessel, a homogeneous mixture which is a dense, cold gas is achieved. This mixture, kept under pressure, is insensitive to weightlessness and is expelled constantly as a single phase fluid. The amount of fluid remaining in the vessel can be accurately gauged by measuring the fluid density.

Many changes have taken place in rocket technology since the days during World War II when the largest German rockets, the V-2s, stood boiling off liquid oxygen in their test stands.

Although 20 years or so have passed since then, the use of liquid oxygen as a fuel oxidizer (the V-2 burned alcohol with liquid oxygen) is so practical and well established an approach that it is still the workhorse fuel, and only in the last few years have other cryogenic fuels come into conspicuous use.

In fact, it was this very broad, high quantity use of liquid oxygen as an oxidizer that was a major factor in the growth and development

This remote desert test site near Boron, California was one of the first important cryogenic test and laboratory facilities established, and contributed to Garrett's leading position in this field.



of cryogenics.

To control the many phases of handling liquid oxygen, and now the more difficult lower temperature cryogenic fuels being used in advanced rocket engines, AiResearch Manufacturing Division, Phoenix, is producing a complete line of cryogenic valves and control systems.

This equipment includes both the lightweight, airborne valves and controls which fly with the missile or space vehicle, as well as the larger, higher pressure and capacity types which are a part of the ground support system.

The jobs these valves do are critical ones, and the requirements they must meet, including high reliability, are stringent. A typical application would be filling a rocket with fuel or oxidizer.

When empty, the propellant tanks are normally pressurized with a gas to maintain the rigidity of the thin walled tanks against the massive weight of the entire vehicle. During the fueling, the pressurizing gas must be let out at exactly the same rate as the cryogenic fluid is rushing in, to avoid over or under pressurization.

The AiResearch system maintains the gas pressure when the tanks are empty, controls the propellant

flow coming from ground storage to the tanks during fueling and makes the adjustment of the remaining gas pressure to the incoming fuel. The missileborne portion of this system continues to maintain pressure in the tanks as the propellant is used up, by allowing a stored gas to take its place.

This system, involving ground fill and drain valves, airborne pressure regulator and shutoff valves, and airborne relief regulator and vent valves, represents only a portion of the valves and other components being produced in Phoenix for numerous cryogenic applications.

Also, this knowledge in cryogenics is being added to 20 years of experience with high temperature, high pressure aircraft systems for the development of valves and controls systems for space engines, including the control of cryogenic fuels for nuclear powered rockets.

The Bowcroft facility of AiResearch Los Angeles is also expanding its product lines in the field of cryogenics. Primarily concerned with manufacturing ground support equipment, in cryogenics as well as their other product lines, the organization works on relatively large capacity equipment,

It is becoming active in cryogenic refrigeration systems for space simulator use, and closed cycle systems for long duration storage of cryogenic liquids.

A major study project, as well as hardware development effort, is under way on a portable liquid oxygen generating plant producing up to two tons of fluid per day. This system will be powered by an AiResearch Phoenix small gas turbine, making it lightweight and air transportable.

The fact that the corporation is putting the broad and diversified experience of its divisions to work on so many aspects of cryogenics, and that many new products have already resulted, is a good indicator of the potential in this field.

Cryogenic equipment which has military, communications and business applications has already been discussed, and these are now the major areas. But already cryogenic research has invaded chemical, medical and metal treating fields, and the first indications show great possibilities.

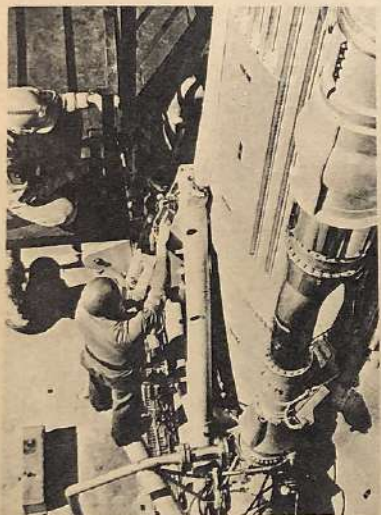
The future, viewed in the light of these first discoveries and products, appears to be very promising. The Garrett Corporation will continue to help make it so.

ALBUM

X-20

FLIGHT

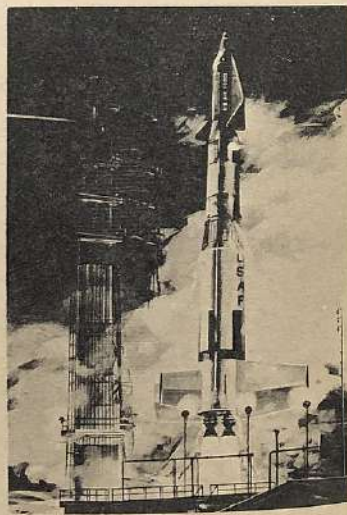
The Air Force X-20 is ready for launch into earth orbit by a powerful Titan III. After launch into space, the X-20 will enter an earth orbit and by a controlled re-entry into the atmosphere, the pilot will bring it back to a conventional landing on earth.



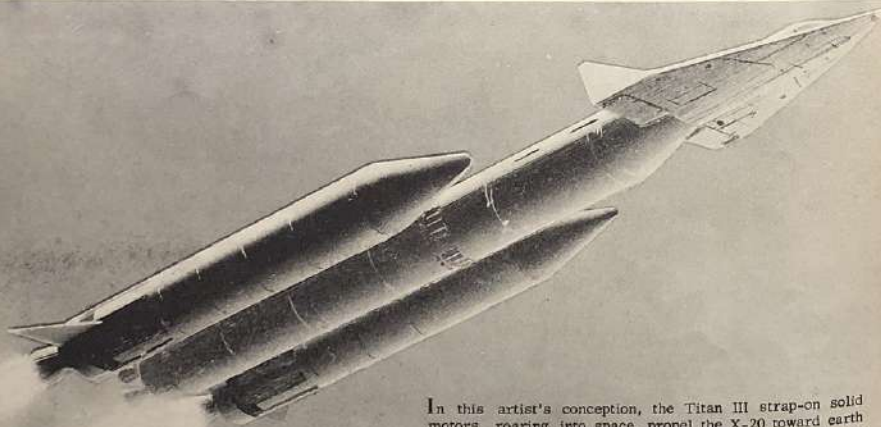
AiResearch Phoenix cryogenic vent and relief valves are shown on Atlas booster at launch site, Cape Canaveral, Florida.



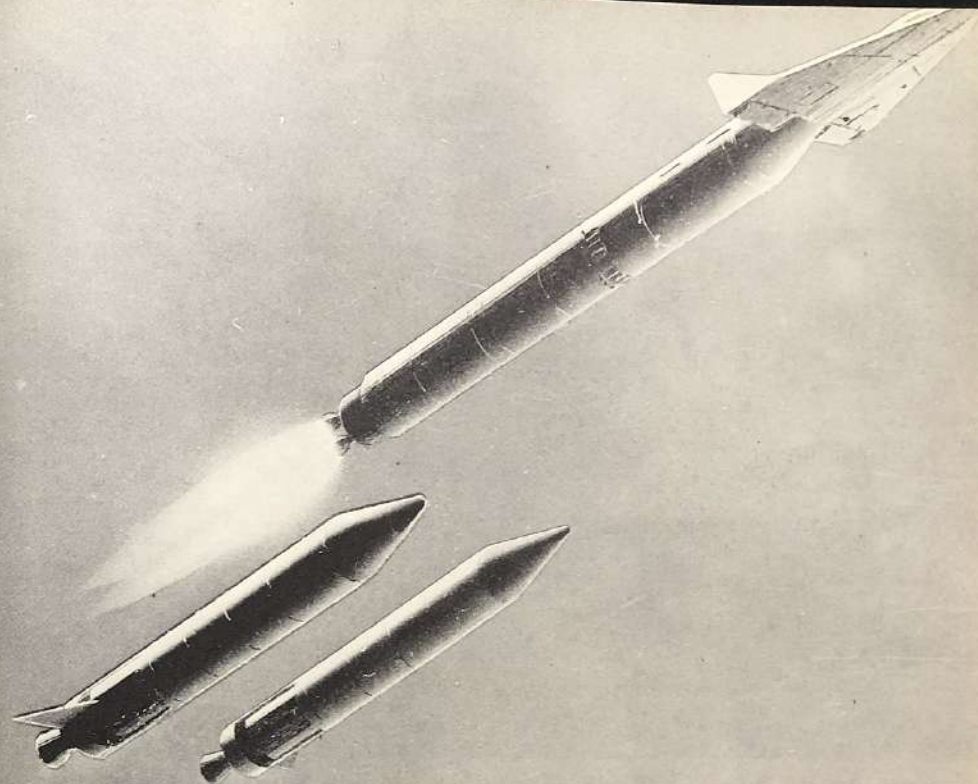
Phoenix-built Garrett ground support valve is buried with Atlas in a silo, Vandenberg AFB (left). Dyna-Soar space vehicle perched atop booster will use Garrett cryogenic system (right).



Over 2 million pounds of thrust literally "kick" the X-20 into space. Two five segment solid rocket motors, each producing over a million pounds of thrust, give the Air Force Titan III additional lifting power for the Dyna-Soar vehicle. Titan III is the first launch vehicle to be developed from the outset as a space booster.

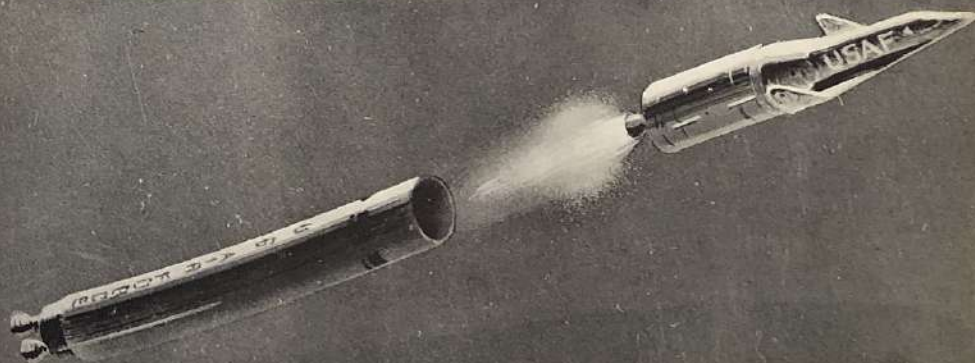


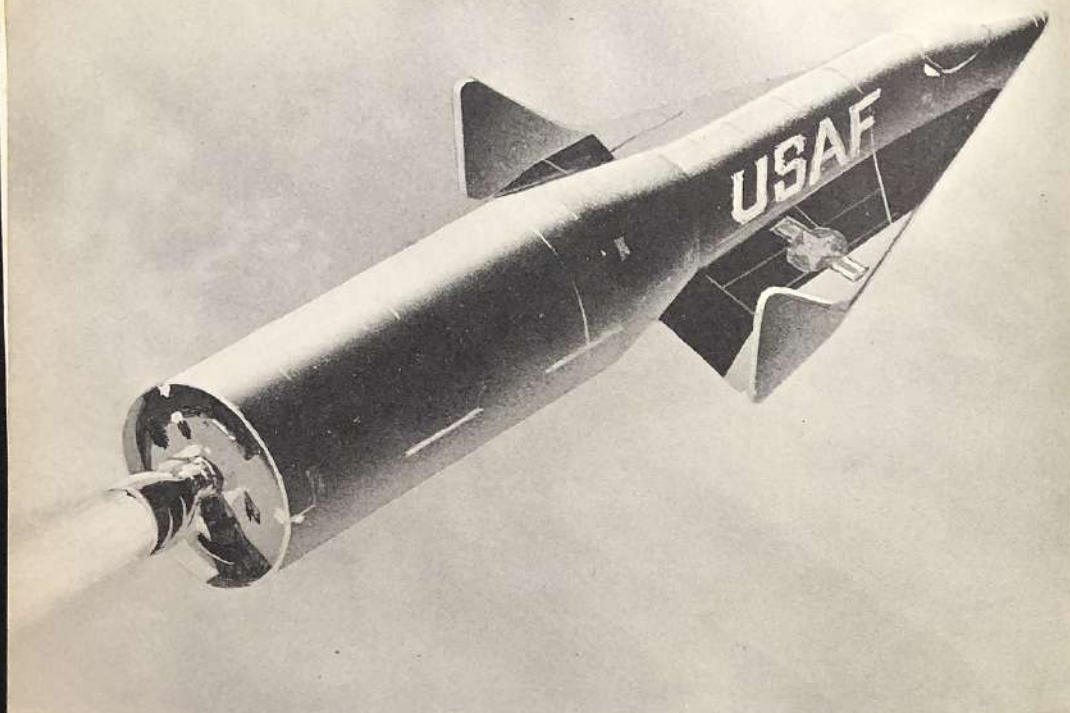
In this artist's conception, the Titan III strap-on solid motors, roaring into space, propel the X-20 toward earth orbit. Producing over a million pounds of thrust each, the two strap-on solid motors give the Air Force Titan III additional lifting power during the first boosting stage.



Depicted here after burnout of the strap-on solid motor, first stage ignition of the Titan III takes place and the solid motors fall away from the faster accelerating Titan core. Producing a thrust of 430,000 pounds, the first stage of the core will continue the X-20 on its course until first stage burn-out and second stage ignition. Acceleration will be continuous until the X-20 enters earth orbit at speeds of more than 17,000 miles an hour.

The X-20, still mated with the upper stages of the Titan III, separates from the second stage of the huge booster. First stage of the Titan III consists of two 120-inch, segmented solid propellant rocket engines.



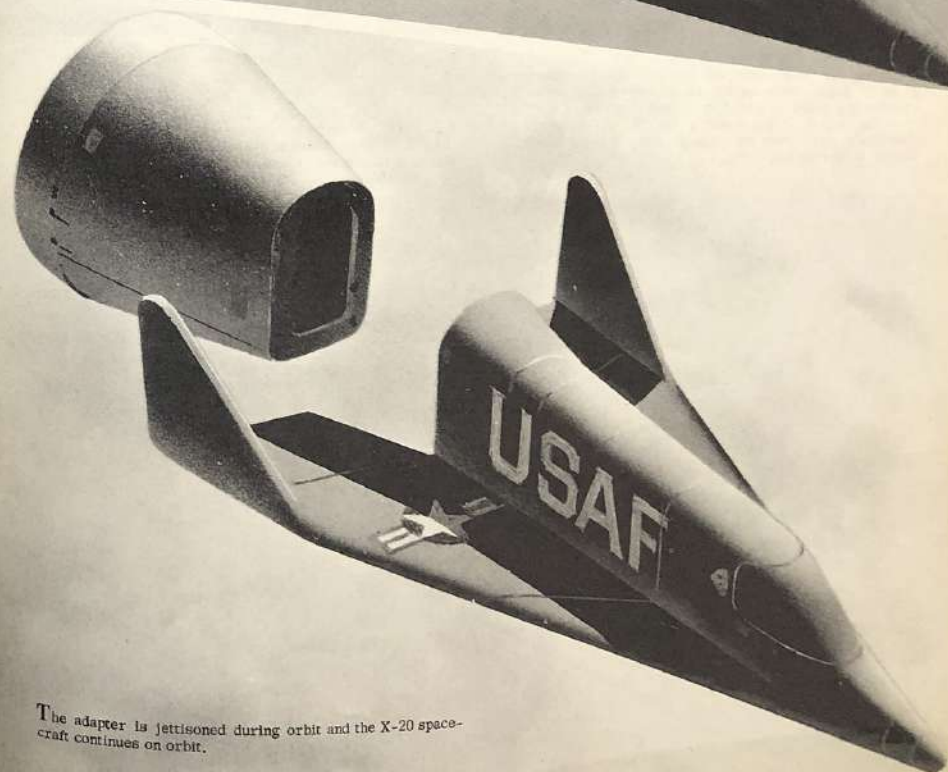


The X-20 goes through a series of coast and powered phases of flight as it is positioned for injection into its final orbit.

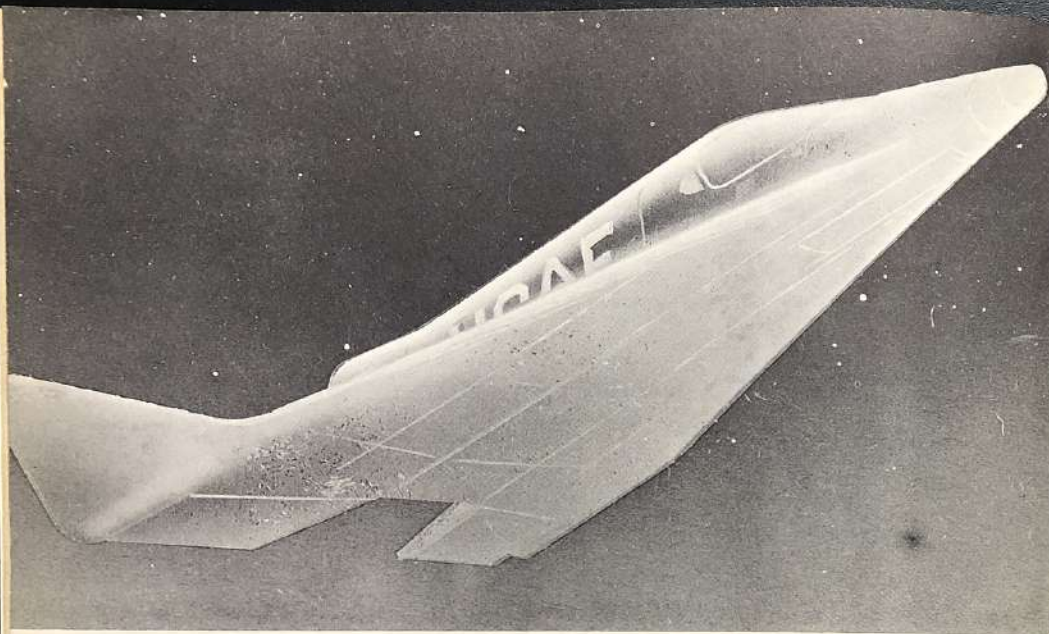
The X-20 is separated from the third stage of its Titan III launch vehicle. The transtage, not shown here, will provide the final thrust vector necessary to inject the X-20 into the desired orbit.



The X-20 with its adapter section still mated, enters earth orbit.



The adapter is jettisoned during orbit and the X-20 spacecraft continues on orbit.

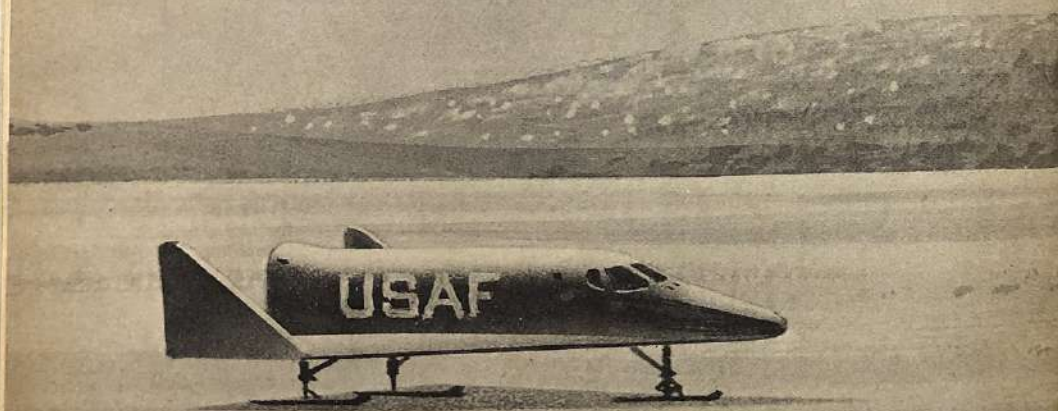


Parts of the X-20 glow with the heat of 4,000 degrees F as the spacecraft re-enters the atmosphere. The air in front of the glider is heated up to 20,000 degrees or more from the impact of the speeding vehicle. As this super-heated air flows over the plane it will look like a comet blazing across the sky.

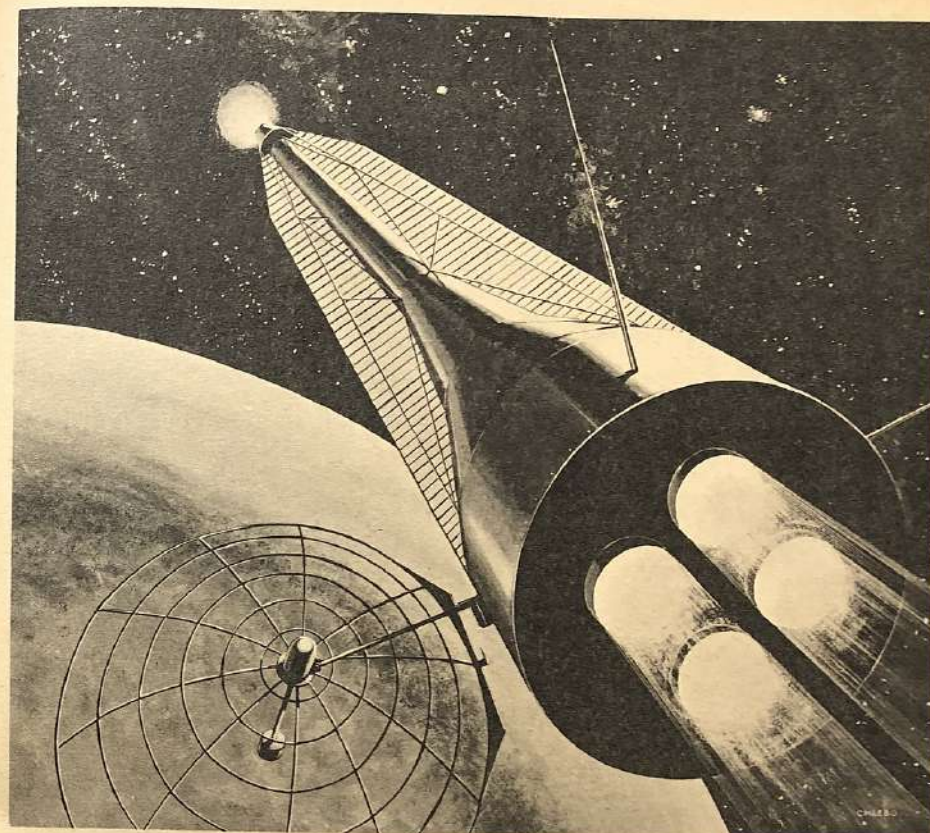
The X-20 pilot discards the no-longer-needed cockpit heat shield so he can see to land.



The maneuvering for the final landing approach on return from earth-orbit, the X-20 demonstrates the inherent reliability and accuracy of controlled, piloted aircraft.



The flight into space comes to an end as the pilot lands the X-20 on its wire brush skids at the selected air base. The X-20 after speeding around the earth at thousands of miles per hour, lands slower than some of the jets in use today.



SPUR

Mapping Mars is a typical possible future flight mission utilizing SPUR (Space Power Unit Reactor), a 350 kw turbine power plant. This system is now undergoing development testing at Garrett-AiResearch, Phoenix, Arizona. Fully developed, the SPUR powered spacecraft could photograph and survey any of the near planets. In this AiResearch artist's concept electricity produced by the SPUR power plant energizes ion engine cluster, right, which propels craft through interplanetary space after separation from a Saturn-type launch vehicle. Radar, communications, photographic and survey equipment also use electricity supplied by

SPUR. Energy source for SPUR is a nuclear reactor, glowing on the left, supplying heat to boil liquid potassium which drives an AiResearch turbine-generator inside the central tube. Conical shield behind the reactor protects system from radiation. Flat fins along central tube are radiator panels dissipating system waste heat into space. These flat-plate radiators can be oriented parallel to sun's rays thus intercepting little heat and allowing the spacecraft to approach near the sun. As shown here, mapping vehicle is about 50 feet long by 10 feet in diameter. SPUR can be adapted to furnish electric power for a variety of space missions including manned

flight, cargo transport, communication satellites, space stations, and lunar base installations. Design goals for SPUR include one year of unattended operation in space with a system weight of 3500 pounds and a radiator area of approximately 700 square feet. In 1958 Garrett-AiResearch operated the world's first closed-cycle turbine on alkali metals. The USAF SPUR has been integrated with the SNAP-50 program of the AEC to provide a coordinated AEC/NASA/DOD SNAP-50/SPUR program. AEC has the prime management role in research and development on the power unit of SNAP-50/SPUR.

NUCLEAR PROPULSION

VELOCITY INCREMENT REQUIRED FOR SPACE MISSIONS

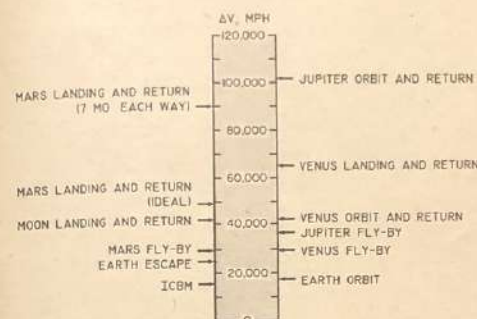


Fig. 1

MOON LANDING

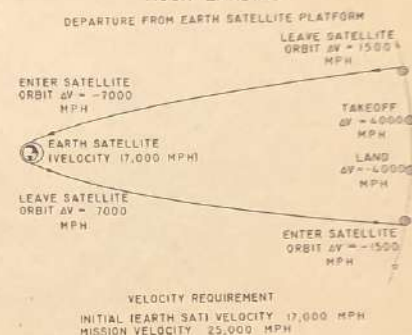


Fig. 2

The object of the rocket engine is to put enough energy or speed into a payload so that it coasts where it is meant to go. It's like throwing a stone - the faster, the farther. Figure 1 shows the velocity that must be put into a payload for each of the various missions listed. The velocity of a mission such as flying to, landing on, and leaving the moon represents the sum of each

step. The steps in this example are illustrated in figure 2. The grand total for all steps, with air braking in returning to Earth, is 42,000 miles per hour.

Fundamentally in rocket propulsion two factors lead to these velocities: the amount of propellant that can be carried in the vehicle, and the energy per pound of propellant. The former is mass ratio

and is dependent on vehicle design. The latter is specific impulse and is dependent on propellant chemistry. Figure 3 shows the relations. If the rocket thrust is applied near Earth, 32.2 feet per second must be deducted for each second of burning; for example, about 10,000 feet per second must be deducted for a 5-minute launch because of work against gravity.

By Walter T. Olson

NASA
Lewis Research
Center

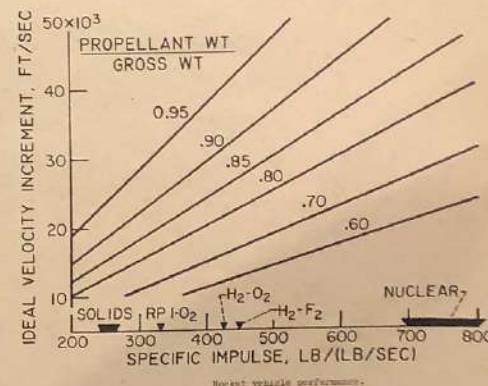


Fig. 3

Of course, one rocket vehicle can be made the payload on another, larger vehicle by staging to build up the ultimate flight velocity needed. For example, the analytical results in figure 4 illustrate the effect of rocket staging on the gross weight required for payloads for different missions. This figure also shows the greater importance of high-energy propellants for the more difficult missions.

VEHICLE WEIGHT REQUIREMENTS WITH CHEMICAL ROCKETS

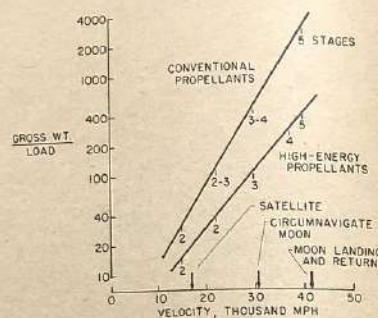


Fig. 4

POSSIBLE USES FOR NUCLEAR ROCKETS

MANNED INTERPLANETARY FLIGHT

UNMANNED PIONEERING SPACE FLIGHTS

UNMANNED SCIENTIFIC EXPLORATION OF ENTIRE SOLAR SYSTEM

Fig. 5

Capabilities

Reference to figure 1 again indicates why the nuclear rocket engine is such a good space power-plant. Specific impulses in the range 700 to 800 pounds per pound per second should be available in the near future, contrasted with 300 to 450 pounds per pound per second for chemical rockets. Even if the heavier nuclear engine and the shielding that it may require permit less propellant to be carried, significant performance gains in terms of ideal velocity increment can be expected. For this reason figure 5 shows some of the possible use of nuclear rockets. A particular example from this listing is shown in figure 6, which gives an analysis of what can be done of one- and two-stage rocket vehicles at a gross weight in orbit of 150,000 pounds. Note the significantly larger payloads or the higher performance for a given payload that nuclear rockets can theoretically achieve over chemical rockets.

NUCLEAR ROCKET PROBE PERFORMANCE

BOOSTER, SATURN C-4
INITIAL WEIGHT IN ORBIT, 150,000 LBS

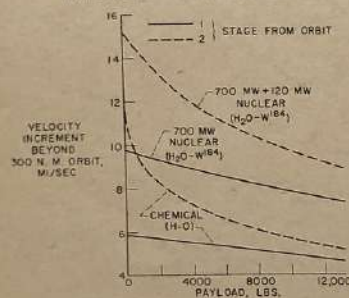


Fig. 6

Rocket Principles

Figure 7 is a cutaway sketch of a hypothetical nuclear rocket engine. Heat in this reactor core is transferred to the propellant. The jet velocity of the propellant, or its specific impulse, depends directly on the square root of its temperature divided by its molecular weight. Hydrogen has the lowest molecular weight, and figure 8 shows that, the hotter it is, the greater the specific impulse is.

At 6000 degrees F hydrogen molecules dissociate to produce hydrogen atoms. The lower ("frozen") curve represents the performance without any recovery of the energy required to dissociate the hydrogen molecules. The upper ("equilibrium") curve represents complete recovery of this energy of dissociation during the expansion of the hot hydrogen from the nozzle.

Technology and Problems

Several kinds of solid-core reactor can be considered for heating the propellant, as illustrated in figure 9. In the homogeneous thermal reactor the highest temperatures occur in the moderator. The purpose of the moderator, of course, is to slow down the high-speed neutrons released during fission of uranium atoms to slower, "thermal" velocities that increase the likelihood of neutron capture by and fission of further uranium atoms. The mixture of moderator and fissionable material is cooled by flowing the propellant through an array of passages or holes from one end to the other. The fast reactor, where no moderator is used, is smaller. The fast nuclear reactions are less efficient, however, and more fissionable material is required for operation. These materials in general are not good structural materials and must, therefore, be contained in a refractory material, such as tungsten or molybdenum. Also, control is more difficult. In a heterogeneous reactor, the fissionable material is separated from a moderator and contained in a refractory material. Both the fuel capsules and the moderator are cooled. In all these solid-core reactors serious limitations are met as attempts are made to increase temperature.

SOLID CORE HEAT TRANSFER TYPE NUCLEAR ROCKET

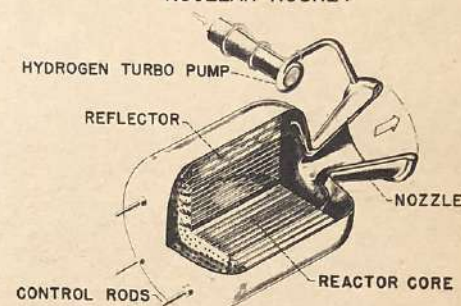


Fig. 7

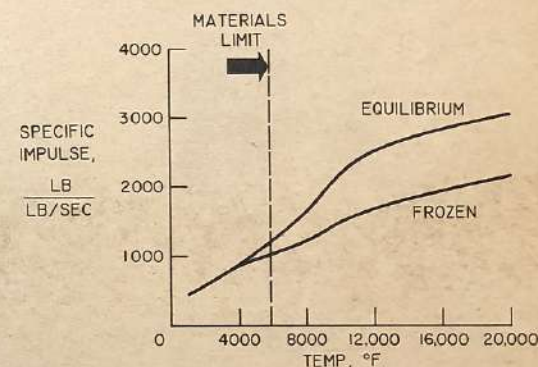
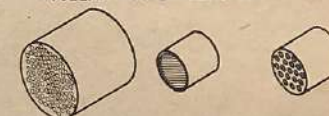


Fig. 8

NUCLEAR ROCKET REACTORS



REACTOR TYPE	HOMOGENEOUS THERMAL (HOT MODERATOR)	FAST (NO MODERATOR)	HETEROGENEOUS THERMAL (COOLED MODERATOR)
MODERATING MATERIAL	GRAPHITE BERYLLIUM OXIDE	NONE	WATER HEAVY WATER BERYLLIUM BERYLLIUM OXIDE METALLIC HYDRIDES
FUEL BEARING MATERIAL	COATED GRAPHITE BERYLLIUM OXIDE	REFRACTORY METALS (W, Mo) CARBIDES (ZrC, HfC, TaC)	REFRACTORY METALS (W, Mo) COATED GRAPHITE CARBIDES (ZrC)

Fig. 9

PROPERTIES OF REFRACTORY MATERIALS

MATERIAL	MELTING POINT °F	TENSILE STRENGTH AT 5000° F PSI	HYDROGEN REACTION	COMPATIBLE FUEL	OTHER LIMITS
GRAPHITE	7000 (SUBLINE)	1000 TO 6000	>2800° F	UO ₂	UO ₂ MELTS AT 4535° F
TUNGSTEN	6170	3000 TO 7000	NONE	UO ₂	
HAFNIUM CARBIDE	7030	2500 TO 4000	>4840° F	UC	DISSOLVES UO ₂
TANTALUM CARBIDE	7020		>4650° F	UC	LOSES CARBON ABOVE 4000° F

Fig. 10

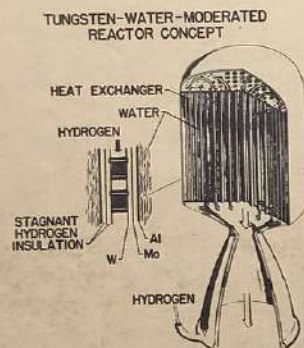


Fig. 11

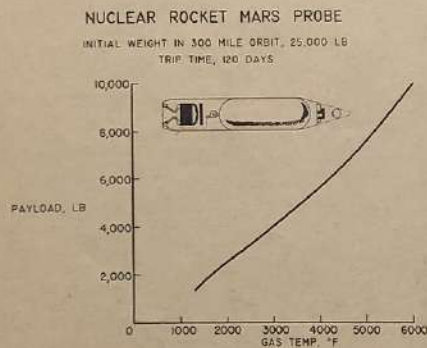


Fig. 12

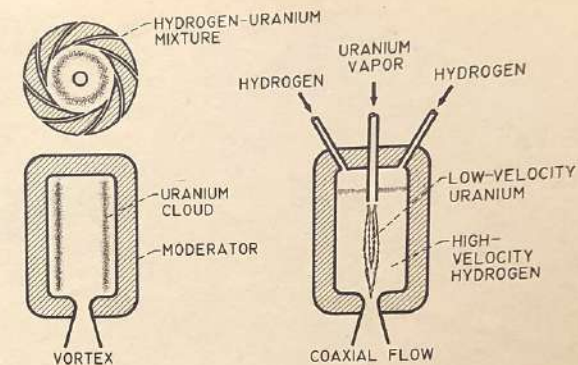
Figure 10 lists the properties of several refractory materials. Since beryllium oxide, a good moderator, is limited to operating temperatures considerably less than those of graphite, graphite is a preferred material for a homogeneous reactor; however, it must be coated because it will react with hydrogen. Core temperatures of about 4300 degrees F and gas temperatures of about 4000 degrees F should be possible.

Tungsten is a likely material for containing the fuel element in a heterogeneous reactor; it must be significantly freed of the tungsten 186 isotope, which captures neutrons that are needed to sustain the nuclear reactions.

Figure 11 shows a design concept for a tungsten-water-moderated reactor. In this case hydrogen is used to cool the rocket nozzle and to remove heat from the water that moderates the neutrons. Finally, the hydrogen is heated to its working temperature by passage across the fuel elements themselves.

Figure 12 reiterates the principle that the hotter the hydrogen can be heated, the better the nuclear rocket will perform. One way to increase temperatures above those that solid materials can withstand is to use reactions in the gaseous

state. Figure 13 shows two concepts of heating hydrogen with a gaseous reactor with external moderator and reflector. By swirling hydrogen in a cavity with the much higher molecular weight, or heavier, fissionable material, it should be possible both to increase the residence time of the fuel and to pass hydrogen through such a reactor with very little loss of the heavier fuel vapor. If the flow rates become very high in the vortex reactor, the fuel is blown out. In the coaxial reactor, residence time is increased by low velocity in the central core. Because heating is largely by radiation, the hydrogen must contain a material to render it opaque to radiation. Other schemes have been proposed.



Gaseous cavity reactor concepts.

Fig. 13

MAJOR STEPS IN NUCLEAR ROCKET PROGRAM

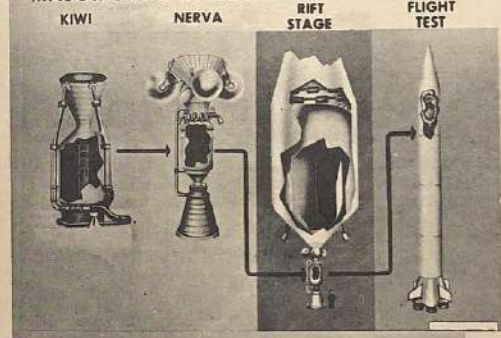


Fig. 14

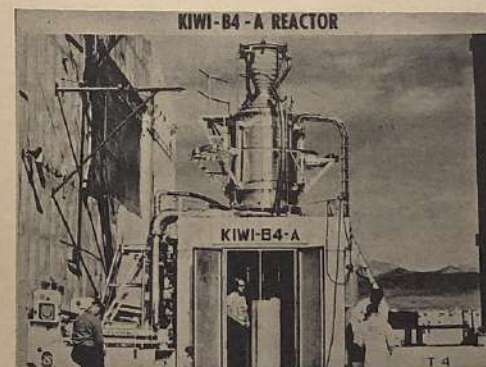


Fig. 15

Current Program of Development

The nuclear rocket program in this country concerns several major hardware elements. Their relationship is illustrated in figure 14. The reactor technology obtained from the KIWI project will be used in the development of a flight propulsion system in the NERVA project. The NERVA propulsion system will be flight-tested in the RIFT stage.

The development of the reactor for nuclear rockets has been under the direction of the Los Alamos Scientific Laboratory, which has tested six different reactors based on the use of graphite materials containing uranium. The most recent reactor test, on the KIWI-B4A, was conducted in November 1962. The reactor is shown in figure 15. In this, as in previous tests, failures of the graphite fuel elements occurred. Both the reactivity of the hydrogen and vibrations at the high temperatures and high flows involved caused these failures. Detailed studies and redesigns are under way currently.

NERVA MOCKUP

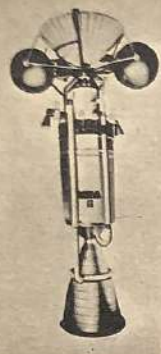


Fig. 16

The NERVA engine will use the reactor development in the KIWI program. It is shown in figure 16. The engine stands 22 feet high. It consists of the reactor, the regeneratively cooled nozzle, control-drum actuators, and the structure to bear the thrust. The pump valve and the gimbal bearing are mounted

within the upper thrust structure. The spheres are gas storage bottles for various pneumatic actuators. Research and development are under way on aspects of this engine, such as the nozzle design and the turbo-pump system.

Figure 17 shows the RIFT stage

INBOARD PROFILE OF RIFT

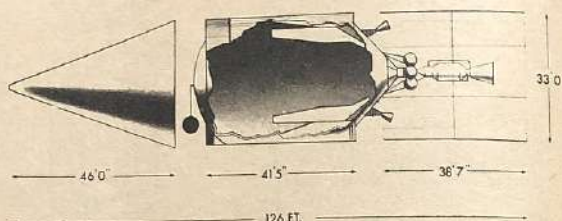


Fig. 17

that is being designed to flight-test the NERVA propulsion system. This stage is planned for the Saturn-V vehicle; consequently, it is 33 feet in diameter. Its height is 126 feet. The total weight will be about 200,000 pounds, with 156,000 pounds of liquid-hydrogen propellant.

BOOK REVIEWS

EXPLORERS OF THE INFINITE:

Shapers of Science Fiction, by Sam Moskowitz (World Publishing Co., 2231 W. 110th St., Cleveland 2, Ohio, 1963, 354 pp., \$6.00). Reportedly the first of a series of books, this excellent work on the past history of imaginative literature will delight all science fiction fans, as well as impress scholars of the genre. Sam Moskowitz, science fiction fan #1, presents fresh viewpoints on early tales which pace the human mind's march into the new frontiers of science/fantasy writings.

Such literary greats as Mary Shelley, Poe, Verne, Wells, Burroughs, and A. Merritt are included for their "pioneering" contributions. Others are literary surprises - Cyrano de Bergerac (first mention of rocket-power for spacecraft), Edward Everett Hale (first earth satellite), and Frank Reade, Jr. (first spacesuit).

A "first" by the author himself is tracing the evolution of new ideas in the past that led to "break-throughs" in story technology, such

as the chain-reaction of authorship creating the explosive new hero-concept of Superman. One other stunning insight Sam presents is that science and space stories are a "third state" of writing - neither fiction-fish nor non-fiction fowl - because they are both. It is only temporary fiction which often turns into future fact. In a sense, authors of this prophetic "fiction" are today's "reporters" of tomorrow's factual "news".

The outstanding example is the vastly underestimated Hugo Gernsback and his Ralph 124-C-41, a super-Vernesque book foretelling with uncanny accuracy, an incredible number of modern science inventions and space technology coups. Gernsback also, by launching AMAZING STORIES in 1926, practically "invented" the entire field of science fiction magazine publishing.

In summary, the history of science fantasy literature is replete with many human phenomena, not the least of which is their chronicler. Sam Moskowitz is a part of science-

fiction history himself, having devoted a lifetime to accumulating massive files on out-of-this-world literature. Also, as the spark-plug of all fandom, fostering fan clubs and fanzines galore, he is their unchallenged chief under the title of "Mr. SF Fan".

PROFILES OF THE FUTURE: An

Inquiry into the Limits of the Possible, by Arthur C. Clarke (Harper & Row Publishers, N.Y.C., 1963, 234 pp., \$3.95). Arthur Clarke, as everyone knows or should know by now, conceived and published back in 1945 the basic idea of communications satellites linking the whole world into a radio/TV/telephone network, leading to the Echo, Telstar, Relay and Syncom satellite experiments of today. He has also been a top contributor to both the field of science fiction and non-fiction.

The 19 essays in this volume - some new, some old and updated - deal with any given phase of mankind's future civilization, including robots, galactic exploration, nuclear

power, anti-gravity devices, time travel, and all other significant technology triumphs to come (or not to come). Spiced with his usual wit and seasoned with uncannily canny foresight, this book is probably as close to a working crystal-ball as one can find. If Clarke has left out any conceivable variation of future scientific progress, it would have to be as unpredictable as the sun suddenly winking out tomorrow.

HARNESSING SPACE, Edited by Willy Ley (Macmillan Co., N.Y.C., 1963, 314 pp., profuse diagrams and illustrations, \$6.50).

Another early great of science fiction who has turned mainly to space-age non-fiction writing is represented in this year's crop of outstanding books. Willy Ley, who needs no introduction, has turned out another encyclopedic resume of space technology, featuring the near-future astro-wonders ahead.

Such forthcoming "commercial" space hardware as satellite weather-forecast systems, worldwide radio/TV orbiters, and navigation-aid devices are thoroughly explained, as well as research vehicles, space labs, and the man-in-space program leading to moon landings - and beyond. Quoting and excerpting mainly from official government and NASA publications on space technology, Willy Ley has surpassed similar books to give the most clear-cut picture yet presented, of the why-and-how of America's mighty space effort.

IS THERE LIFE ON OTHER WORLDS?, by Poul Anderson (Crowell-Collier Press, N.Y.C., 1963, 223 pp., \$4.95).

Moskowitz, Clarke, Ley, and now Anderson. The latter is a science-fiction trained fourth who turns from mere fantastic tales to the more fantastic realities of space travel unfolding before us today. Step by step, from the first stirrings of life on earth eons ago to its probable genesis elsewhere, the author builds up the case for fauna and flora on billions of planets throughout galactic space. Intelligent beings would be confined to only a "few" - a few millions, that is, Far from "wild", this concept is now firmly

accepted by almost all the cosmological, biological and anthropological authorities all over the world. What Poul Anderson does is to explain why they are all so convinced that some day soon - within 10 years - our radio-telescopes will pick up the first "message" from outer space - the first of many thousands, all of which have been inundating earth for centuries. It is not the weak signals of other-world senders that are at fault - it is our primitive radio-receiving technology. They are there and we don't know it - yet. As Isaac Asimov says, in his foreword to this book, "I feel certain that no one who reads this book will ever look up at the stars without a twinge of wonder, of a kind he never felt before."

All three of the above are by Martin

Caidin, top-flight writer in the aviation/aerospace field for many years. Each is of value to the space-oriented pro and layman both. The Man-in-Space Dictionary covers all major aspects of manned spaceflight techniques and the concomitant astro-technology, conveniently arranged in alphabetical order. In Overture to Space, the author expounds on the notorious "Space Race" with the Soviet Union, present sobering new (and well documented) indications that "the nation which rules space will rule the earth". For teen-age "juveniles" (i.e., not written down to adults), By Apollo to the Moon is a living, breathing resume of just how, before the decade is out, three astronauts will leave footprints in the lunar dust. Included is every piece of hardware - booster, spacecraft, life-support system, astro-guidance devices - in authentic detail.

EXPLORING THE SECRETS OF SPACE, by I.M. Levitt and Dandridge M. Cole (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1963, 306 pp., illustrated, \$5.95). Dr. Levitt, head of Fels Planetarium

in Philadelphia, has authored previous well-done books about space. Dandridge M. Cole, astro-engineering specialist in Advanced Space Systems for General Electric, has published many prior articles relating to space-age projects. In collaboration, these two space experts have produced as close to an astronautics "textbook" as has yet been achieved - but a textbook that laymen will easily understand. Behind the conquest of space are little-known basic science bricks which the authors explain lucidly, to make the "baffling" art of astro-technology much less perplexing to the general public.

AUTOMATION by Andrew Blumle (World Publishing Co., N.Y.C., 1963, \$3.95). Full coverage of computer and automation systems.

INTERPLANETARY DYNAMICAL PROCESSES by J. Parker (John Wiley & Sons, Inc., Publishers, N.Y.C., 1963, \$12.50). Technical. For the Astronautics profession.

SPACE SCIENCE edited by Donald P. LeGalley (John Wiley & Sons, Inc., N.Y.C., 1963, \$17.50). Technical. For college students and professionals.

A HISTORY OF ROCKETS AND SPACE by Courtlandt Canby (Hawthorn Books, Inc., N.Y.C., 1963, \$5.95). Many illustrations, diagrams, color photos.

INSIDE THE NUCLEUS by Irving Adler (The John Day Co., Inc., N.Y.C., 1963, \$4.95). Basics of nuclear physics.

ATOMS AND THE UNIVERSE by Jones, Rotblat, and Whitrow (Charles Scribner's Sons, N.Y.C., 1963, \$4.50).

DOCTOR OX'S EXPERIMENT by Jules Verne (The Macmillan Co., N.Y.C., 1963, \$3.95).

THE MOON, METEORITES AND Comets Volume IV The Solar System by B.M. Middlehurst & Gerard P. Kuiper (The University of Chicago Press, Chicago 37, Ill., 1963, \$15.00). Technical reference.

JANUARY 50¢

SPACE WORLD

The Monthly Magazine of Space News

**EXCLUSIVE! How It Felt To Ride The Vostok Into Space:
GHERMAN TITOV'S OWN STORY!**

IN THIS ISSUE:

- How They Catch Satellites In The Sky
- Willy Ley's 4-Page Newsletter
- NASA's Five-Year Plan
- Your Life On The Moon

Actual photo of Earth
taken by Titov on
August 6, 1961.



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ORBITING AROUND

JUPITER GREENHOUSE?

In the light of startling discoveries made by space vehicles, the science of astronomy is undergoing an upheaval, with new theory daily supplanting the old. Latest cosmologic blockbuster was dropped by Dr. Carl Sagan, astrophysicist of California University's Space Sciences Laboratory. Performing a small pilot experiment simulating Jupiter's heavy atmosphere of mixed gases (methane, ammonia, hydrogen, others), Sagan backs up his speculations that the Jovian air may act as a "heat trap," letting infra-red solar radiation in but not out. Hence, instead of the classical theory of a shivery temperature at minus 207° F., Jovian surface vegetation may enjoy a balmy 70° above. Even more revolutionary is Dr. Sagan's suggestion that this "greenhouse" temperature would have formed oceans of mixed water and ammonia, into which multi-atom organic molecules would fall from the pregnant air. And this process, as on earth, would inevitably support evolutionary processes leading from molecules to men. Thus Jupiter—and other outer planets—may not be the frozen lifeless wastes heretofore envisioned. There may actually be living Jovians who, as their telescopes peer earthward, conjecture if life is possible on that "over-heated" planet that is only 93 million miles from the blistering sun.

FIRST SPACE AGE FAIR

Tomorrow's world is emerging in Seattle, Washington, where the \$80 million *Century 21 Exposition* is fast taking shape for opening next April. It will be the first U. S. world's fair in 23 years. Tagged "America's first Space Age world's fair," *Century 21 Exposition* will seek to stimulate man's curiosity as he looks to the years ahead and the miles above. Lasting from 21 April 1962 to 21 October 1962, 35 nations are expected to participate in *Century 21 Exposition*, and will sponsor their own large national exhibits. Such American corporations as AT&T, General Electric, Standard Oil of California, General Motors, Alcoa, and others have leased space in exposition structures or are building their own pavilions. U. S. government participation is among the largest of all. The U. S. Science Pavilion promises to be a "radical departure" from other technological exhibits, being planned as a complex of five buildings clustered around a fountain plaza featuring five arching towers. One exciting exhibit will be the "Spacearium" where a new concept of image projection will give visitors a simulated ride through the heavens spanning 2 billion light years in 10 minutes. Another

feature is a 600-foot steel-and-glass tower crowned by a restaurant and observation deck that will revolve at the rate of one full turn per hour. This Space Needle will soar higher than the majestic United Nations building on New York's skyline. Visitors will be able to reach the 74-acre Exposition grounds from downtown Seattle (a distance of one mile) in 96 seconds via the nation's first public-transit, full-scale monorail.

UNDERGROUND LUNARIANS

According to scientists of the Martin Co., who are studying earth-lunar transport systems, the most practical way to establish a permanent moon base will be to tunnel underground. A shield of rock above the colonists would protect them from above-ground hazards such as space radiation, large falling meteorites, and extremes of temperature. A lunar thermometer on the lunar surface will show a range from plus 250° F. during the daytime to minus 230° at night. But a few feet underground, temperature probably stabilizes at about minus 45°, no worse than the Antarctic winter conditions on earth. The underground dwellings could easily be made comfortable for the colonists by means of electrical heaters whose current can be supplied by efficient fuel-cells or atomic reactor generators. An artist's visualization shows a Martin concept for a lunar boring machine that tunnels down and digs out the necessary space required by the moon camp crew.



TWICE-TOLD TELEMETRY TALE

A prize-winning "space first" for America is the only instrument used in two different satellites. Telemetry signals from the USAF's Discoverer XXV, launched June 16, had a familiar sound. And well they might, for its telemetry set was the same one utilized in Discoverer XVIII, launched December 7, 1960.

"Timeless T," as this unique telemetry set may be known if it goes into additional orbits, functioned perfectly on both flights and came through undamaged. The December 1960 recovery from orbit was by air snatch, and the June 1961 recovery was effected by an Air Force pararescue team who parachuted into the Pacific when the capsule landed north of the intended impact area.

According to Discoverer satellite engineers at the Lockheed Missiles & Space Company, the twice-orbited telemetry set is as good as new, and probably will be sent up again in a future Agena-B vehicle.

'BOUNCING ROCKS!'

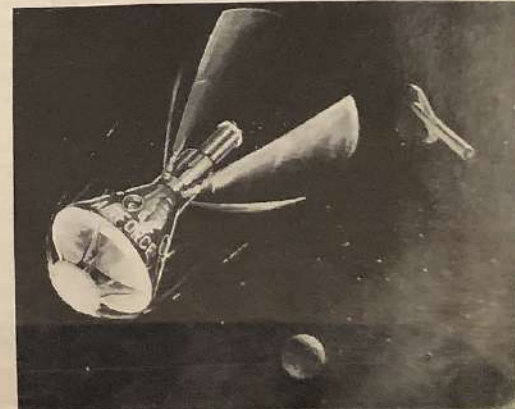
"Bouncing Rocks," which look, feel and act like rubber but are actually made of stone are being developed as an elastic material capable of withstanding the tremendous temperature extremes in space, for use in gaskets, lubricants and other "accessory" needs of vehicles. Recognizing the fact that common old rocks are practically impervious to extreme heat, Dr. Joseph Feltzin, Research Chemist at Aerojet-General Corporation, has turned to the rockpile. He pulverizes the rocks, further breaks down the basic atomic particles, then combines the particles with appropriate chemicals. The result: "Bouncing Rocks," a rubbery product which already has withstood 600 degrees Fahrenheit for long periods without burning, disintegrating or losing its vital elasticity. The same principle promises earthly benefits too—long-wear tires, lubricants and hydraulic fluids for civilian and commercial uses. And the key to it all—the simple rocks of the earth.

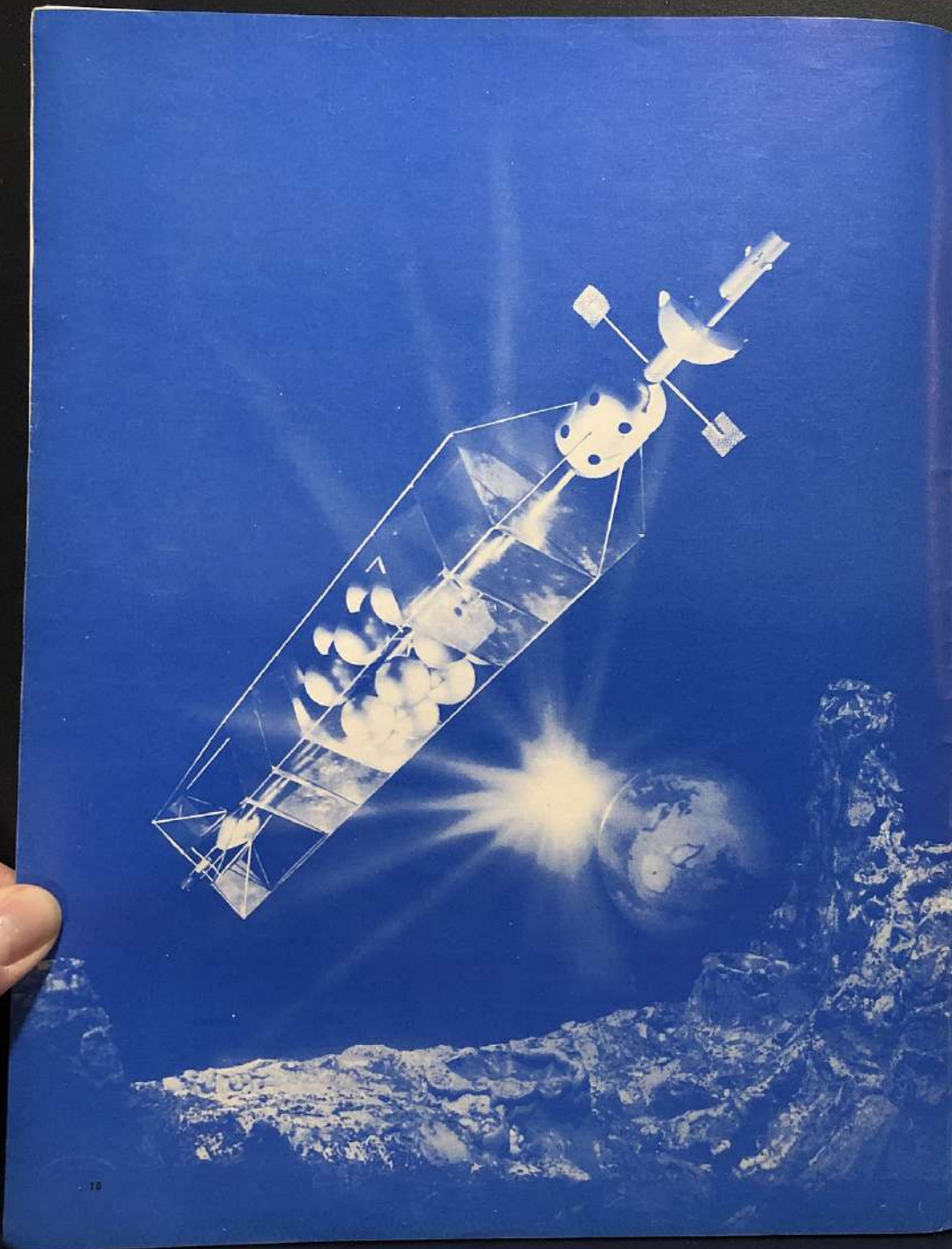
SATURN SHIELD

Scientists and engineers at the NASA Marshall Space Flight Center—charged with the far-reaching responsibility of getting giant Saturn rockets off the ground and around the moon—have been faced with many problems. One of these is the tremendous amount of heat generated at the tail of the mammoth Saturn C-1 rocket by its eight clustered H-1 engines—about 4,500 degrees F., or twice the temperature that the Mercury spacecraft encounters when it returns to earth after orbiting. Marshall engineers had to come up with a "heat shield" to protect the booster engines' fuel pumps, valves, instrumentation lines, control equipment and other critical components situated at its base. A special insulation applied to a fiberglass fabric was developed, with added layers of a silicon rubber, a silica fiber fabric and a reflective coating. This multiple insulation scheme was necessary to make the curtain resistant to both convective and radiant heating. About 2,000 pounds of it is used for the shield. How important to the Saturn are these anti-heat measures? Engineers estimate that the big rocket could get no higher than 500 feet off the ground without them.

NEW RE-ENTRY

This artist's conception depicts one of the possible future applications of the Rotochute which is being studied by Kaman Aircraft Corporation, Bloomfield, Connecticut, in a contract with the USAF. In this application the Rotochute would provide initial deceleration for a manned capsule being returned from orbit. Further down in the atmosphere the Rotochute idea working on the same principle as a helicopter could be used to further slow the capsule's re-entry and guide it to a chosen landing site. Kaman has already built and made experimental drops with more than 1500 Rotochutes. This new contract calls for Kaman to add guidance controls to its present Rotochutes and to study the feasibility of using Rotochutes in the return of large rocket boosters, nose cones and manned space capsules.





MERCURY—SATURN—APOLLO—NOVA

A director at NASA tells what's ahead for those projects in THE NEXT 5 YEARS

by ROBERT C. SEAMANS, Jr.

Frequently I have been asked why we are preparing to send men on hazardous spaceflights when instrumented satellites and probes have proven so versatile in returning information on the space environment.

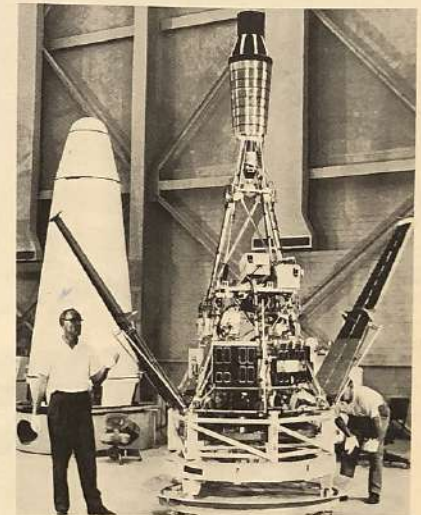
First, integration of a human pilot into an onboard spacecraft system greatly improves reliability. The man cannot only make inflight tests but also inflight repairs. We have striking examples of this in missions of the USAF/NASA X-15 rocket airplane which has been flying to the fringes of space at great speed. In at least eight out of thirty-eight cases to date, the X-15 flights would have failed without a pilot in the cockpit to correct malfunctions of equipment, instruments, or powerplant. In at least as many other cases, if X-15 missions had been unmanned, we would have obtained no information because either instruments or telemetry failed. The X-15 pilot, however, was able to land with valuable flight information recorded by his own senses.

Second, while instruments can perform certain tasks of sensing and transmitting statistical information gathered, spacemen are necessary for understanding the larger realities of space. The most advanced apparatus can perform only as it is programmed to do. Instruments have no flexibility to meet unforeseen situations. Scientific data acquired in space mechanically must be balanced by on-the-spot human senses, human reasoning, and by the power of judgment compounded of these human elements.

A man's capacity for storing information is enormous. He requires a minimum of programming. He can change his mind without elaborate and time-consuming reprogramming. His mind is an excellent filter, discarding redundant data with great speed. Man also far outstrips any computer in the ability to make decisions.

Third, we must recognize that *manned flight in space has a much greater impact on the world's populace than unmanned flight.*

Deep Space Probes. New propellant systems will allow detailed exploration of moon and nearer planets.



Ranger Lunar Vehicle. This space vehicle will explore the moon before any manned landings are attempted.

The United States has congratulated the Soviet Union on the orbital flights of Cosmonauts Gagarin and Titov. These achievements were expected because the Russians have a significant lead on large boosters. We should all be prepared for other Soviet "firsts" in space in the immediate future. This serves to underline the urgency of President Kennedy's decision to accelerate our own manned space program.

Finally, it must be realized that in the long run man cannot, by his very nature, be kept out of space. The same drive that led Columbus to explore the outer reaches of the known world will induce modern man to explore the outer portions of the solar system.

The historic flights of American Astronauts Alan

(continued on page 46)



Finishing Touch. Painter Frank Brophy applies finishing touch to model of fork-lift truck used for Agena and Polaris missiles.



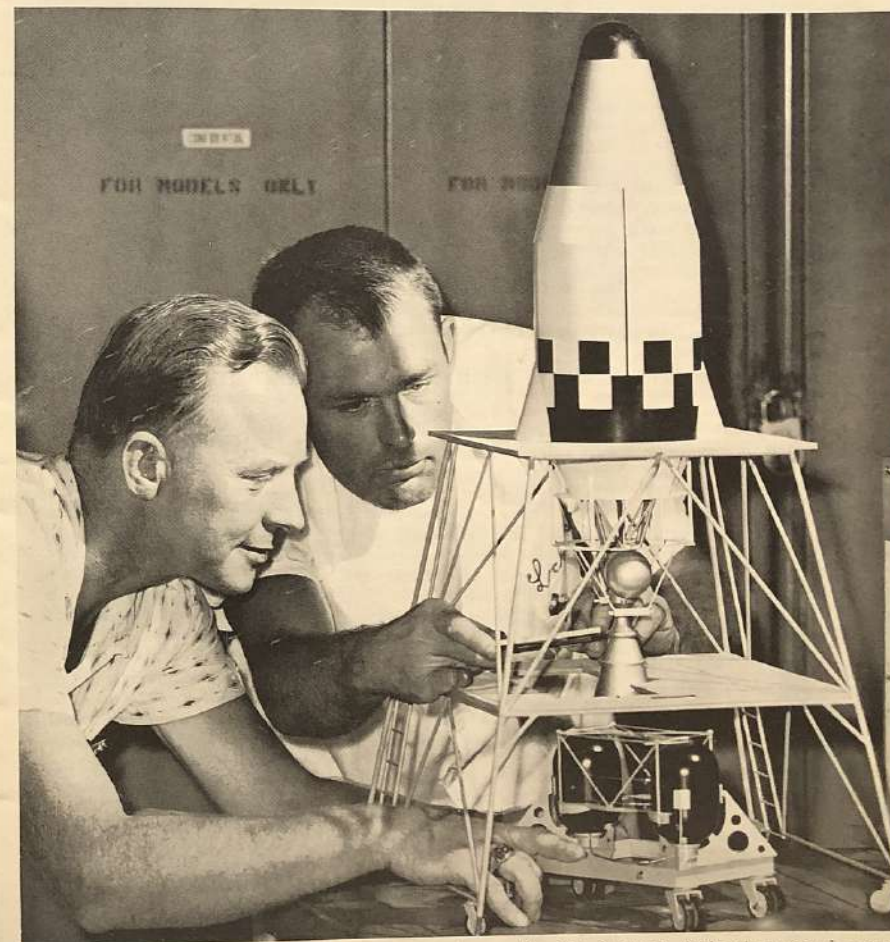
Miniature Capsule. John Blair, model maker, packs parachute into model Discoverer to check fit of components.



Fine Detail. John Gray uses tweezers to make adjustment on handling gantry for Agena.

MODEL MAKERS

BUILDING ROCKETS and space vehicles in miniature is a full-scale job at Lockheed's Missile and Space Vehicle division. A model-making shop at the plant is kept busy full-time in order to meet the demand for precise, miniaturized mock-ups of the company's manufactured hardware. These models are used for sales presentations, engineering studies, personnel training, and by plant engineers for planning production lines. ■■



Fine Fit. Chuck Hurbig, right, fits a movable deck plate into model of Atlas-Agena work stand complex,

while Erik Osterlund checks clearance of ground-handling gear. Models check-out actual equipment.

PROJECT PILGRIM

A step-by-step account of how men will explore and colonize the moon

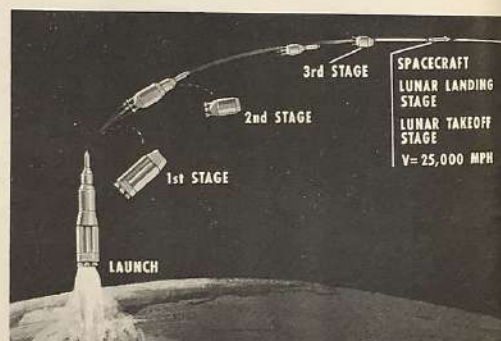
Project Pilgrim is a concept and a program for the establishment of a permanent colony on the moon within this decade, beginning in 1968.

Few doubts remain that men can be technologically equipped to function in the space environment, and will in due course progress to the management of earth satellites and vehicles for exploration of the moon and the nearer planets. Yet, public expressions of current U. S. thinking envision tentative exploration expeditions to the moon in the 1970's, using large new boosters as yet unspecified and based on careful, conservative development.

This plan for rapid manned exploitation of space is in distinct contrast, and stems from these ideas:

1. The needed technologies and basic equipment already exist in plans, laboratory models, modest development programs.
2. The skills, people, and to some extent the facilities needed to proceed already exist.
3. A bold focal plan, combined with funding in definable areas, will initiate the program.

The focal plan concerns a method of establishing small colonies by multiple sequential landings of equipment and men, and the on-site assembly of shelters and necessary equipment, including return vehicles. The Saturn C-2 or C-3 booster, already in development, is the largest vehicle required. An exploration program, based on Atlas-Agena B and Atlas-Centaur, is a necessary prerequisite, including lunar orbiting spacecraft for mapping, lunar impact craft for exploration, soft landing vehicles for exploration and site preparation,



Lunar Mission. Saturn booster, above, will loft exploratory machinery, right, for manned lunar colony.

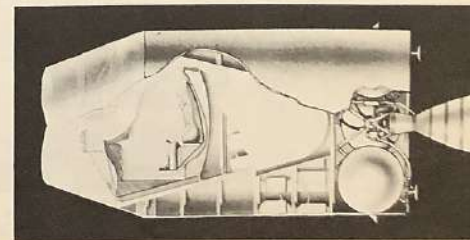
and circumlunar spacecraft for test of the capability to return and land safely on earth.

Colonization of the moon would commence with the selection of a site on the moon for the soft landing of men and material. The first vehicles would consist of lunar landing vehicles loaded with all the essential material necessary for the establishment of a lunar beach-head. After telemetry has indicated that the first vehicles have landed safely, men will follow.

The lunar landing vehicles will be of a modular design so that after they are collected together they can be as-



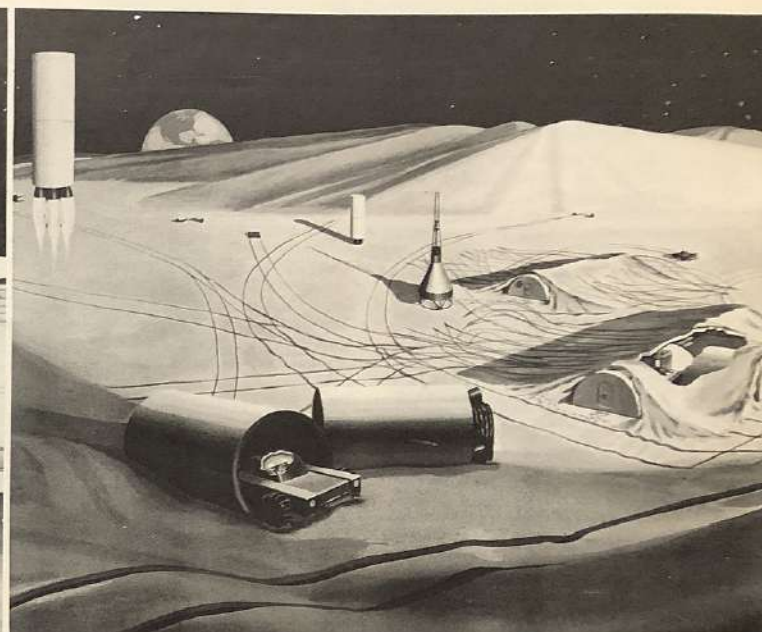
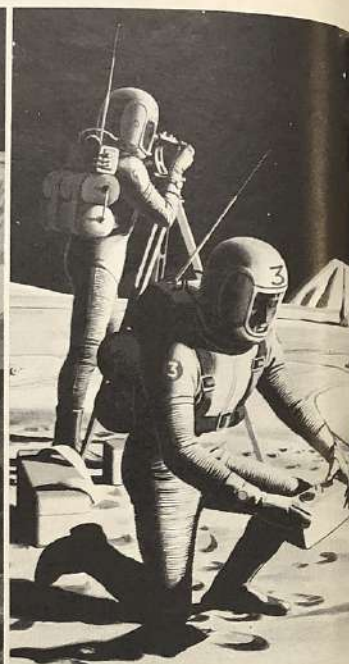
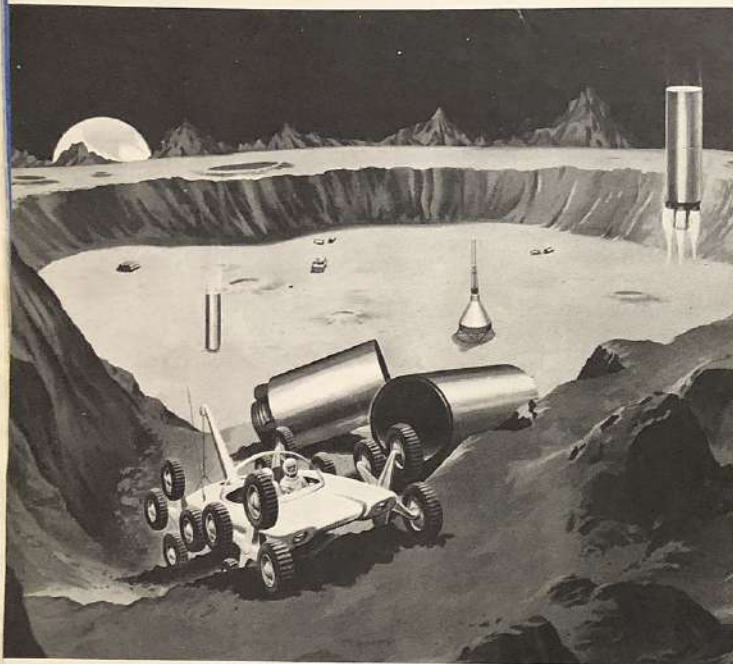
Space Ship. Model, below, is prototype lunar vehicle.



sembled to form efficient and compact housing that would include living quarters, mess facilities, laboratories, shops, power stations, recreation/ward room and storage. Eventually a translucent dome could be built over this housing and additional space acquired for gardening or any other use. Such a base would be self-sustaining for a period as long as a year. It would give the colonists a sense of security and normalcy.

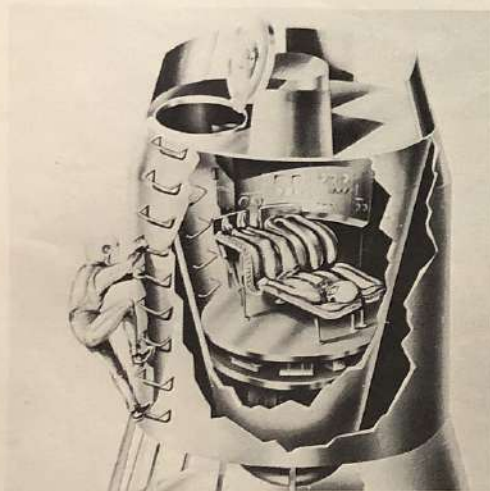
A pioneering group of 10 colonists has been selected as a number which would contain the minimum capabilities and disciplines necessary for the success of this

continued



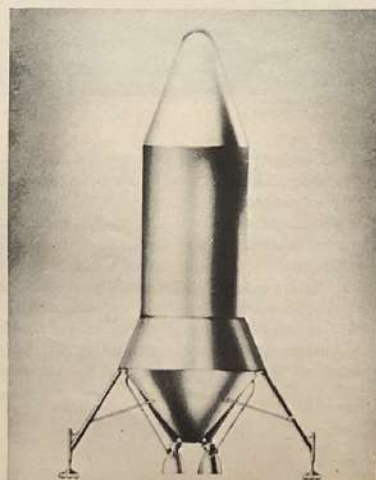
Lunar Conquest. Special vehicle will travel over rugged lunar terrain. After preliminary

exploration is completed, a permanent lunar colony will be constructed on a pre-selected site.



Lunar-Earth Return Vehicle. These drawings show possible design for moon exploration vehicle.

Project Pilgrim will



utilize existing hardware and techniques

mission, yet be redundant enough so that a high degree of safety and efficiency will be maintained.

After the colonists have secured their housing and environment they will assemble earth return vehicles from building block propulsion components previously delivered to the site and consisting of earth re-entry capsules and rocket engine assemblies. The low gravity of the moon ($1/6$ of earth's) will facilitate this task.

During this period the pioneer colonists will ascertain the detailed requirements for the establishment of a permanent colony.

The 10 pioneer colonists and the 500,000 pounds of essential material could be soft-landed on the moon by 200 Saturn vehicles at an estimated mission cost of \$8.0 billion, which amounts to an average of \$1.06 billion, about $1/2\%$ of the Gross National Product* of today.

*Gross National Product \$498. billions.

It will be a lesser percentage of the GNP of 1968.**

The program proposed for accomplishment of these goals begins with a six month intensive study, directed by the United States government and accomplished by an industrial contractor, for the purpose of detailed corroboration of the initial estimates and formulation of comprehensive plans for implementation.

Phase II consists of a six-year period of development, proving of techniques and equipment, and training of colonists. This second phase could be under the systems management of an industrial contractor with the government providing top program direction.

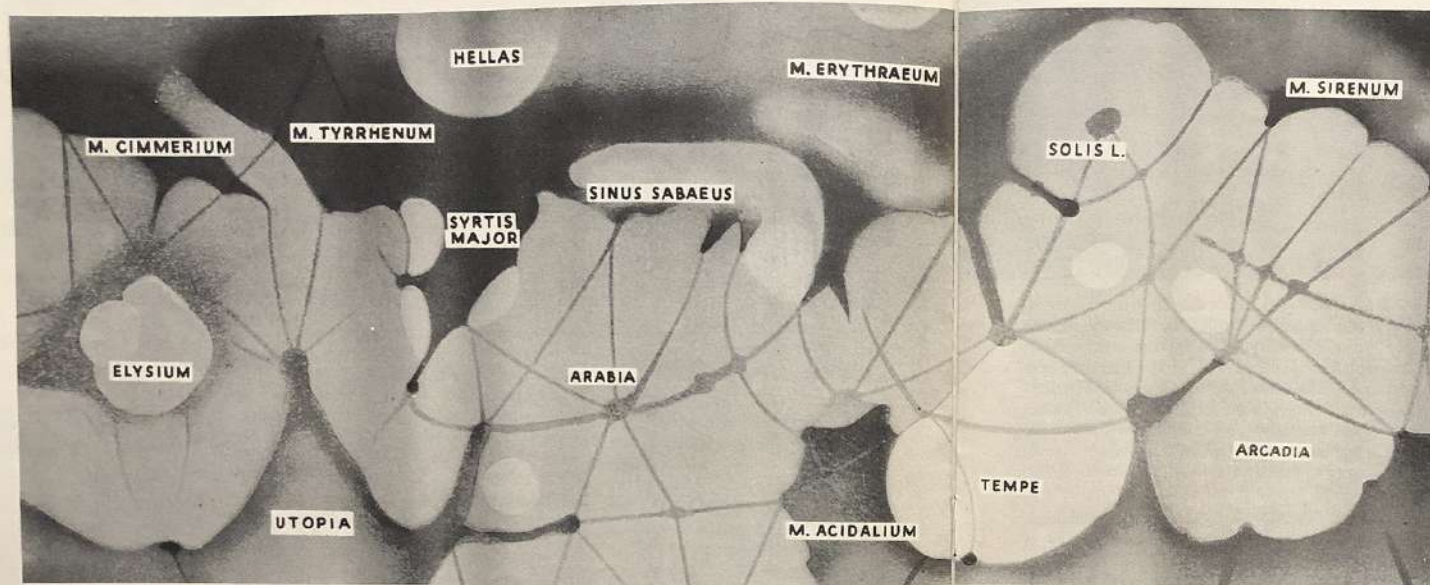
Phase III is the establishment of the initial lunar colony, directed by the government, with services for launch, supply, maintenance and administration of the colony provided by an industrial systems manager. ■ ■

**Estimated to reach \$750. billions.

A famous American Astronomer

discusses

LIFE ON MARS



Clyde Tombaugh offers his views on the controversial question of

In the September issue *SPACE WORLD* published an exclusive article by Professor F. Zigel, Soviet astronomer of the Sternfeld Observatory; titled *There IS Intelligent Life On Mars*. Hardly any other article in our magazine has brought such a flood of mail, pro and con. The majority vigorously rejected the assumptions by which the Soviet scientist arrived at his conclusions that life not only may have existed on Mars in past times—but still does today.

Many readers have asked us to present the other side of this argument. One of these was Clyde W. Tombaugh, the astronomer who discovered the planet Pluto in 1930. Mr. Tombaugh, who now teaches at New Mexico State University, sent data to us which seriously disagrees with Zigel's thesis. *SPACE*

WORLD's editors have summarized Tombaugh's arguments and present them as one answer to Zigel's thesis.

"It would be most interesting for us if there *were* intelligent life on Mars," writes Clyde Tombaugh. "But the odds are terribly against it, and we should all realize this. I have been an assiduous observer of Mars for over 30 years, and was on the staff of Lowell Observatory for 14 years, using the powerful and excellent 24-inch refractor hundreds of times for observing Mars. I strongly disagree with the author's [Zigel's] interpretations . . ."

Though Tombaugh doesn't agree with Zigel's conclusions, the American astronomer does not deny the existence of the canals. Quite the contrary:

intelligent life on the red planet

"I have seen nearly 200 of the so-called canals of Mars . . . too well to relegate them to illusions as many astronomers have done. I endeavored to find a more plausible explanation of the canals and their origin."

Along with most other astronomers, Tombaugh does not accept the theory of a vast network of waterways to "irrigate" Martian crops. It would have been a staggering engineering job, even for a race facing extinction, Tombaugh believes, to pump water from the poles of Mars all the way to the equator.

Furthermore, the American astronomer continues, if the Martians had the technology to crisscross their planet with giant canals, why should they choose this "primitive" method of crop irrigation for survival? Why



Martian Canals. Dr. Tombaugh says there is not enough evidence to make conclusions on this Mars mystery.

not the much simpler and more efficient development of hydroponic "greenhouses" in which a dwindling amount of precious water could be re-used and re-cycled through the tanks in which the crop roots dangled? Moreover, the Martians would surely know the simple fact that many rocks hold water of crystallization in loose chemical bondage, which can easily be broken by mere heating to release water vapor. The construction of a planetwide system of irrigation canals smacks too much of combining engineering comparable to that of 20th century earth with the outdated agricultural pursuits of the ancient Egyptians. It doesn't "ring true".

Tombaugh goes even further. The late Percival Lowell postulated that Mars once had earthlike oceans which gradually evaporated, forcing the Martians to build their canal network. Tombaugh questions whether extensive Martian seas ever existed. Upon drying up, their bottoms should have become sterile salt-beds, as with many ancient seas on earth—notably the famed salt flats at Edwards Air Force Base where the X-15 takes off and lands. But it is precisely the lowlands of Mars that today exhibit the greenish hue of vegetation.

This would then mean, Tombaugh goes on, that even long ago this desiccated planet could never have supported forests or growths of large woody plants. Ergo, there could be no deposits of coal laid down underground by burial of forests through geological upheaval. Nor could oil have formed as a special stage of forestations being fossilized.

(continued on page 58)

FEBRUARY 50¢

SPACE WORLD

The Monthly Magazine of Space News



WAR IN SPACE

CAN AMERICA WIN IT?

THE CHALLENGE OF SPACE WAR

We at SPACE WORLD believe that the American people must be made aware of the startling astro-military projects coming in the near future. Beyond the ICBM, the rocket and nuclear bomb can together fashion even deadlier devices for space warfare. Ominous signs from beyond the Iron Curtain lead us to believe that we are already in a war whose battlelines are drawn in the laboratories and industrial plants of the USA and USSR. We must work around the clock to win this science war—and thus deter actual space aggression—if we are to survive as a free nation. Only by building invulnerable space defense systems can we prevent the First—and Last—Space War. SPACE WORLD is grateful to General Bernard Schriever's AFSC, and particularly to Major James F. Sunderman of the USAF Office of Information, for invaluable aid in preparing this special issue.*

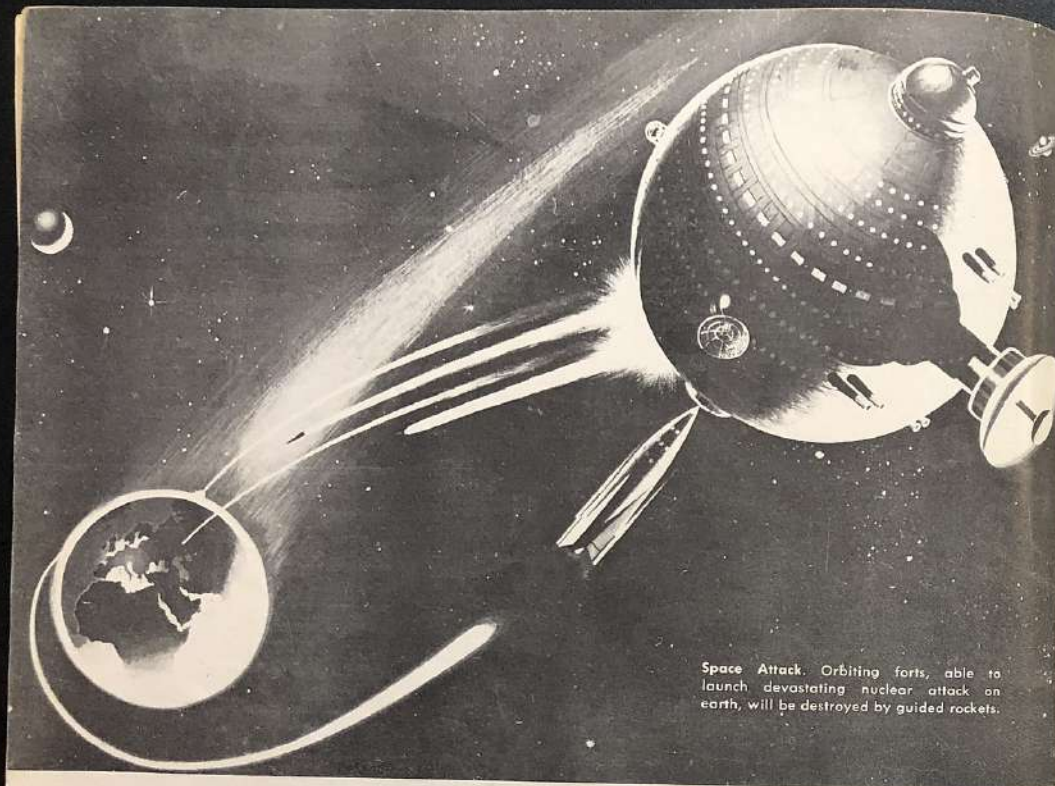
*This does not imply endorsement by the USAF of opinions and interpretations for which SPACE WORLD is solely responsible.

IF SPACE WAR COMES

Here are some of the things we can expect:

- 1 ICBM ATTACK
- 2 VOSTOK BOMBERS
- 3 SPACE TORPEDOES
- 4 ORBITING HYDROGEN BOMBS

turn page →



Space Attack. Orbiting forts, able to launch devastating nuclear attack on earth, will be destroyed by guided rockets.

New space weapon systems are changing concepts of war

by ERNEST HAUSSMAN

"We must avoid a nuclear Pearl Harbor in space,"

... Major General John B. Medaris suddenly, the box on the wall labeled "Yellow Alert" began flashing. An alarm clanged. In precision, sixteen pairs of eyes swung to the Iconorama, the 3-dimensional monitor screen connected to all the attack-warning radar fences—Ballistic Missile Early Warning System (BMEWS), Space Detection and Tracking System (SPADATS), and Space Surveillance (SPASUR). These electronic eyes probed far above America and Canada, watching every tiniest object in space that came from the north, east or west.

In the underground hush of SAC's Command Post at Offutt, Nebraska, only the quickened breathing of the technical crew was heard as they saw three blips on the monitor. In long familiarity, they quickly dismissed one. Just Vanguard III's routine overpass. The

second was mentally scratched as space junk, an empty rocketshell from a Russian launching last year.

The chief scientist didn't have to say it aloud. *What was blip three?*

Soviet ICBM trajectory over the North Pole? . . . No, wrong curve. New satellite? . . . No, speed too high by at least 8000 mph. A giant meteorite barreling in from outer space? . . . Yes, right angle, right speed, right characteristics. But . . .

"Coming in straight toward us," muttered the SAC commander uncertainly, already reaching toward the buttons. "I don't like it. Not that a big meteor can't come in like that, but . . ."

Only seconds had passed. The commander wasted another second as his finger hovered over the two buttons. No, not the RED ALERT. Not unless positive identification proved the unknown was an attacking device. Chances were better than 99 per cent it was just a big bruiser of a meteor coming at America's

heart by cosmic chance. But no harm in pressing the BLUE ALERT.

Instantly, a humming network of telephone, teletype and radio code signals sped to the 60 U.S. and 20 overseas bases of the USAF's Strategic Air Command. At every airfield, men scrambled from the barracks to warm up their huge B-52s. At every missile site, the countdown began as a Niagara of fuel poured into giant Atlas and Titan ICBMs.

In fifteen well-rehearsed minutes, the massive nuclear strike force of American retaliation would be poised for take-off at the final word. That word could only come from the White House and Pentagon.

Fifteen minutes? The SAC commander's haunted eyes were transfixed on the moving blip of Unidentified Object X. Time zero for its collision course with earth would not wait for fifteen minutes.

He snatched the Gold Phone. Automatic circuits went through to Pentagon Headquarters of the Joint Chiefs of Staff. And to the white-pillared sanctum of the Commander-in-Chief of all U.S. armed forces. The SAC commander bit out the briefest briefing he had ever made.

He was also pulling out teletype tape whose clacking source was the SPACETRACK center far away, where all the tracking data had been processed by massive high-speed computers.

"Probability of meteor is now high enough," he said over the Gold Phone, "to call it a false alarm. Will halt Blue Alert and—"

The monitor chief interrupted: "Object changing course slightly. Retro-rockets and verniers, obviously." He added, "Commander, it is not a meteor."

The SAC commander snapped explanations into the Gold Phone, punched the Red Button for counterattack, rang the NORAD alarm.

Within minutes, the North American Air Defense Command headquarters at Colorado Springs would be ready to unleash its jet fighters and anti-aircraft Nikes to battle the invader. SAC's own counterattack Strato-fortresses and ICBM missiles would be ready to get off the ground in the allotted time.

All the NORAD defensive phalanx and SAC offensive might was geared to sighting enemy missiles arching from around the world at least 15 minutes before they could reach target America.

The SAC Commander pulled the Strategic Target switch that automatically set all nuclear warheads, whispered the confirming code word for attack to all B-52 bombers, and alerted the Mirror SAC Command Posts around the land.

SPACETRACK's teletype unemotionally reiterated that between the first sighting of the non-meteorite non-ICBM and its calculated arrival only 3.07 minutes would elapse.

The monitor followed War Object X as it corrected its trajectory, trimmed its speed, and swooped down



Nuclear defense. Hydrogen bombs, exploded in space, will be utilized to destroy fleets of enemy rocket bombers.

through the Van Allen Belts to the precise geographical midpoint of the U.S. When it reached the 500-mile altitude mark, the blip burst into a nova.

Nobody in America really saw the 20-gigaton fireball that exploded in space, spraying forth radiation energy equivalent to that of 20,000 one-megaton bombs, over Maine, Florida, Texas, Idaho, California. Over all America. A split-second barrage of neutrons riddled New York, Chicago, Los Angeles, and all lesser cities, killing everyone in the open.

Next came a space flood of infra-red rays that set America on fire from coast to coast. Finally, a roaring tornado of hyper-heated air picked up the grounded SAC bombers and Atlas missiles and shredded them, 12 minutes before they were to have flown.

There was no fallout from the super space bomb. There was no need for it. No life was left to destroy, down in that nuclear junkyard of what had been a nation, ten seconds before . . . continued on next page

A single gigaton hydrogen bomb could destroy most of America



This grim glimpse into a possible nuclear hell that may lie in the future is based on data from Dandridge Cole, astronautics expert of General Electric's Missile & Space Vehicle Division. The 20-gigaton bomb, he points out, would only be 200 times more powerful than a 100-megaton bomb—which in turn is equal to 10,000 of the original 20-kiloton bombs.

Other authorities warn that we cannot ignore the possibility of the new space dimension and its formidable technology being applied to fantastic astro-nuclear weapons. Dr. Donald G. Brennan of MIT also agrees that very high-yield thermonuclear devices could be exploded in the space over America with holocaustic results. If Russia is developing her monster bomb series in the multi-megaton range to eventually reach energy forces of several hundred megatons, then even from above the atmosphere one of them could "destroy half the continent," warns Dr. Brennan.

This, combined with advanced rocket technology, could lead to attack against which America had not the slightest chance of either defense or retaliation. Our entire warning system could be befuddled if the enemy simply used his powerful boosters to inject the bomb

into the proper elongated trajectory, so that it would seemingly approach from outer space. Neither our electronic devices nor our human judgment could tell it apart from a meteor—until too late.

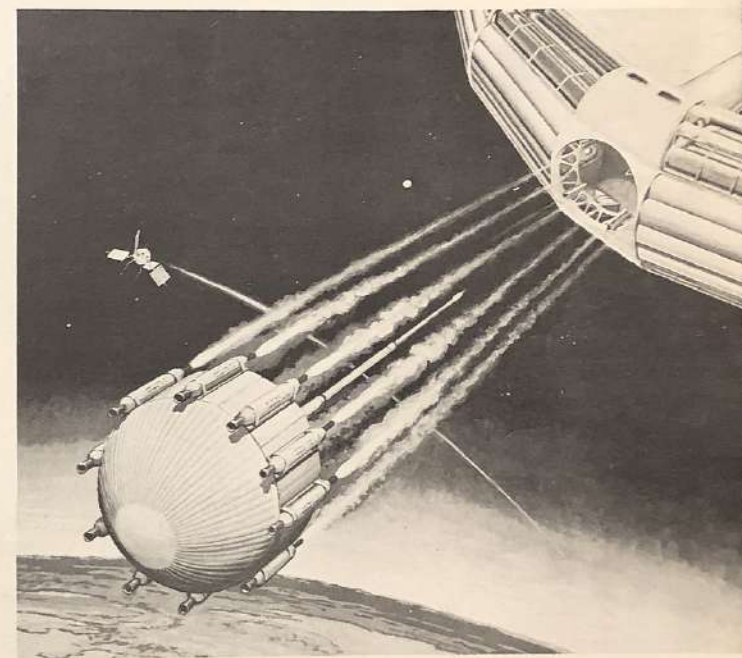
The sober lesson from this is that ICBMs are not the "ultimate" weapon. To believe that is to re-live the same foolishly optimistic era when eminent scientists called the unborn ICBM "impossible." That was exactly seven years ago. Before the next seven years march by, ICBM warfare—which after all is merely rocketry applied to earthly artillery—will be primitively obsolete. Space military weapons concepts of awesome power will take their place.

There is a shuddery lesson in this for us today, because of the galloping pace of technology in our astro-nuclear age. *Any breakthrough achieved by Soviet science leading to one, or more, space weapons systems would enable Russia to conquer the earth.*

General Bernard A. Schriever, Chief of the Air Force Systems Command which develops all future weapons, warns: "In this nuclear-rocket age, a new Sword of Damocles hangs over the Free World. For the first time in our nation's history, America is open to surprise

Space Bomber. Launched into orbit, this bomb platform could form an almost impregnable carrier for nuclear bombs that could attack earth with almost no warning time for defenders below. The first nation to orbit such a bomb platform would enjoy an almost overwhelming military advantage over its opponents.

Nuclear Space Ship. Artist's drawing, left, shows nuclear powered space craft that could be used for transporting heavy loads to the moon, or to more distant points, to build and maintain either military or scientific bases. This ion-powered craft would be erected in low orbit.



nuclear attack—from ICBMs today, from more startling space systems tomorrow."

There is growing evidence that the Soviet's Vostoks were not ballistic vehicles like our Mercury capsules, but aerodynamic delta-wing craft like our Dyna-Soar. A strong clue comes from postage stamps issued by Russia and its satellite nations, which consistently show an orbital booster whose top-stage Vostok is a winged spaceships.

And when asked once by an American reporter if the Vostoks carried any bombs, Khrushchev replied: "No, but they were big enough to."

Another significant space experiment occurred just before Gagarin's flight. When Sputnik VIII was orbited on 12 February 1961, a wholly new astronautics technique—only theorized in America—was performed in reality by the Soviets: re-launch from orbit.

Their first giant vehicle in that shoot corresponded to a space platform placed into a parking orbit. This allowed it to circle the earth several times until it reached the optimum firing position for a Venus trajectory. Then, upon ground command by radio, an auto-

matic re-launch sequence took place in orbit to fire the true payload—their Venus probe, weighing 1419 pounds.

Though this Soviet Venus probe lost its radio voice and never fulfilled its mission of sending back data during the Venus flyby (May, 1961), the orbit-launch feat itself was a stunning success. Our first attempt at using this technique with the Ranger 1 (September, 1961), was an "abort" even though low orbit was achieved. The next re-launch sequence failed and the probe simply remained in earth orbit instead of being propelled some 680,000 miles into translunar space as planned.

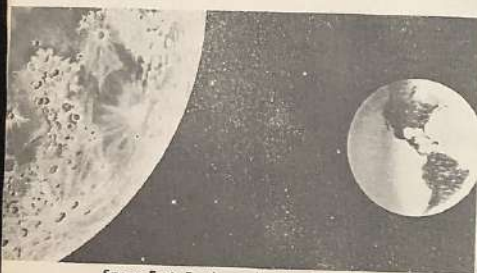
The ominous portent of the Soviet success in this space first is that such an orbiting "launch pad" could just as easily send its payload to another planet—earth. In short, it could be the pilot model of a Soviet orbital bombing base.

This brings up a widespread fallacy about orbit-bombing being inferior to or more tricky than using earth-based ICBMs.

Captain Robert C. Truax, advanced rocket expert for

(continued on page 50)

Why we must beat the Russians TO THE MOON



Space Fort. Earth can be dominated by moon base.

by DANDRIDGE COLE

What are the reasons for sending men to the moon? Is it important that Americans land there before the Russians?

The question of national prestige has received considerable attention. However, the Panama Theory advances a more urgent motive for manned flights to the moon. The moon may be vital for the conquest—in both the peaceful and military senses—of the Solar System.

The moon can be the Panama Canal of space. It may serve as the "gateway" to outer space and the other planets just as the earthly Panama Canal is a key link in the chain of ocean commerce stretching across the Atlantic and Pacific.

Lunar advantages will be many if it serves as a spaceport to the Solar System. Because of its low gravity and lack of heavy atmosphere, it can become an excellent refueling station for vehicles making longer space flights. The nearest planets—Mars and Venus—are at least 100 times further.

However, this depends on the availability on the moon of propellant materials, notably water, which can be broken down into hydrogen and oxygen. A number of scientists now predict that water-of-crystallization in the lunar rocks is almost certain to be found. Harold Urey, I. M. Levitt, and Thomas Gold are among the prominent astro-experts offering this theory.

Water, decomposed by electricity, means hydrogen gas, which is not only a chemical rocket fuel but a nuclear "fuel"—that is, a reaction mass for propulsion. It is easy to show the advantage to a military space commander of a fleet of nuclear deep-space patrol

In this symposium SPACE WORLD has invited three authorities to discuss the moon as a strategic military base and as a gateway to the rest of space. They offer some expert opinion as to why America must make an all-out effort to establish the first permanent colonies on the moon's most strategic sites

ships, if there's a source of hydrogen on the moon. It would be much easier to refuel a nuclear Mars-bound vehicle with hydrogen exhaust material on the moon than on earth.

The moon is a big place, and a Russian base complete with propellant manufacturing plant would not necessarily preclude a similar installation by the U.S. The question then is the best availability of hydrogen ores and the Soviet lead in establishing its moon bases.

The picture can become grim, depending on that lead time. Suppose that the Russians land on the moon five years ahead of the U.S., allowing them time to set up several bases, and consequently stake a claim to the whole body. Then any attempt by America to land on the moon could be declared an aggression and our spaceships would be shot down forthwith.

With only a two-year lead, the Russians might still take possession of both lunar poles—the most likely places to find water in the form of ice. There are other materials and natural formations—extensive caves perhaps—which are more likely to be discovered by the first ones on the scene. It is therefore important that we do not give the Soviets a possibly critical exploratory advantage in time by failure to compete in the moon race.

by TREVOR GARDNER

It is entirely possible that in two or three decades the scientific, economic, technological and military importance of the moon will cause us to consider it as valuable as certain pieces of real estate on earth over which major wars have been fought.



Lunar Base. Manned colonies on the moon will prove invaluable for both military and scientific applications.

It is not too fanciful to believe that in 1981, we will consider the acquisition of the moon more important than was the purchase of Louisiana, or of Alaska.

The lunar project is a natural focus for vast space activity that will be required for a large scale military, scientific and technological utilization of space.

The unhappy reality of our time is that we must apply space technology to war weapons for our national safety. None of the recent scientific and technological enterprises—atomic and hydrogen bomb, nuclear-powered submarine, Polaris IRBM, liquid ICBM (Atlas) and solid (Minuteman)—compare in magnitude and complexity with the lunar program.

We must marshal our resources and manage them with great skill in order to achieve success on a schedule which the ingenuity of scientists of the USSR have already established for us. They are going for the moon as fast as possible, by their own admission.

The Soviet space program is a direct challenge to the security of this nation. The USSR seeks to demonstrate that their military capability is superior to ours.

President Kennedy's moon program could be our nation's only answer to the Soviet challenge. ■■

by HOMER BOUSHEY

As regards the moon, I personally believe it could, at some future date, be used as a secure base to deter aggression. The establishment of a lunar base, as a combined military/scientific venture, could greatly benefit free mankind. I for one would not like the Russians to prove to us that the moon is a useful military site, for our future may be determined by the result.

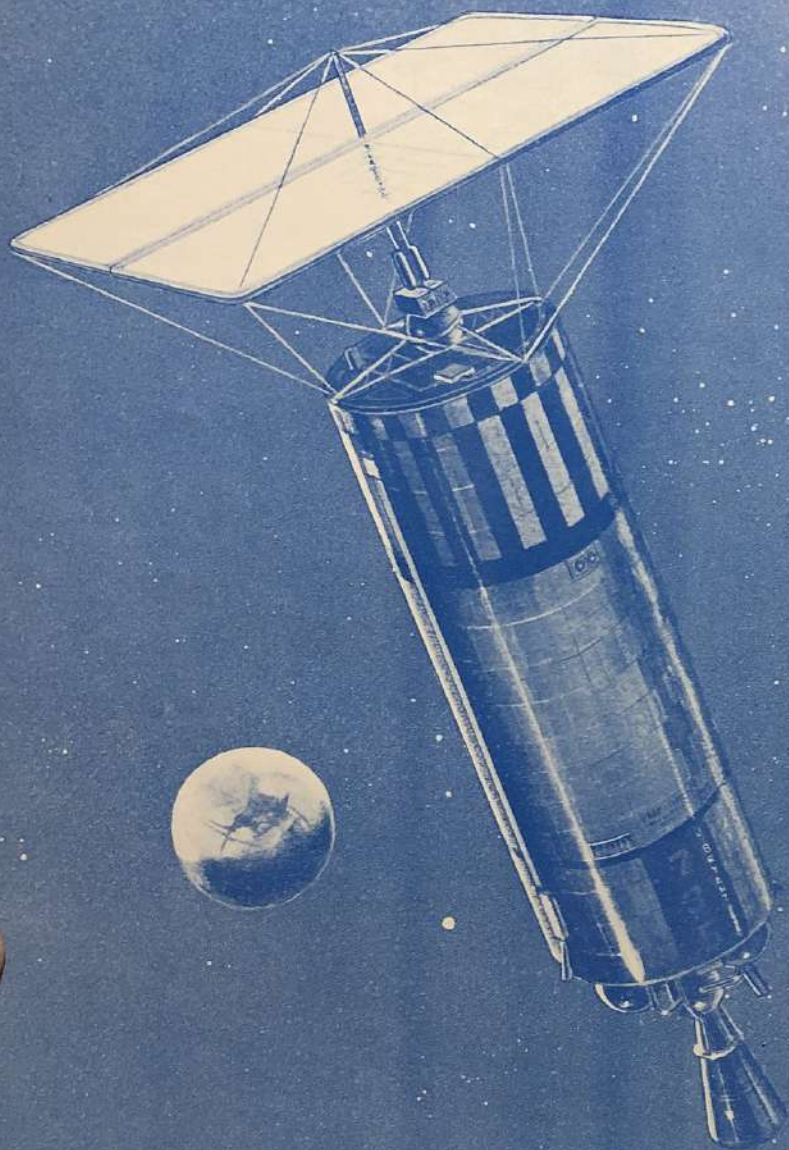
Shall we, or the Soviets, find the answer?

The control of the earth lies, in my opinion, in controlling the moon. Only through success in our lunar endeavor can we command the "high ground" of space operations—namely, the moon.

From an energy standpoint, only 1/5 or 1/6 the rocket-fuel is required to shoot a warhead from the moon to earth, as vice versa. Since there is no atmosphere, perhaps warheads could be catapulted from shafts sunk deep into the moon's surface. Sufficient velocity might be imparted by the catapulting itself, such as RATO plus the mechanical spring system for launching jets from Navy aircraft carriers, to reach lunar escape-velocity—about 1/5 that for earth [1.5 miles per second v. 6.9 mps.].

A missile attack launched lunarward from the earth could be observed from the moon, with perhaps 48 hours to take counteraction. Even if a nuclear detonation occurred near or on the lunar surface from an earth-launched weapon, there would be no blast effect since there is no atmosphere. And protection against thermal, X-ray and neutron radiations from the bomb would be easy, for there would be many hours' warning time to compute lunar impact locations and for personnel to go underground.

Last, and most important, the moon provides a retaliation base of unequalled advantage. If we had a base on the moon, either the Soviet Union must launch an overwhelming nuclear attack toward the moon first, 2 to 2½ days prior to attacking the continental U.S., or the Reds could attack the continental U.S. first, only and inevitably to receive from the moon, some 48 hours later, sure and massive destruction. ■■



Our next generation of space systems and weapons will mark the transition from air power to space power and will make space itself the battleground of the future

by MARVIN KEPLER

"As we look into the future of space weapons, we find some fantastic proposals . . . but seeing what has happened in space in the last three years . . . I have confidence many of these wild dreams are technically feasible" . . . Major General Osmond J. Ritland (Chief, Special Weapons Command, USAF/AFSC).

The asteroid Hermes once again approaches earth, coming within one million miles. A small number of hydrogen bombs are exploded on its surface in such a way as to deflect it from its orbit—into a collision course with earth. This rocky ball one mile in diameter is deliberately aimed toward impact on the U.S., an impact having the devastating effect of a 1000-gigaton nuclear warhead, equal to ten thousand 100-megaton bombs. All life is snuffed out by the violent implosion of blast-waves in the atmosphere above America . . . which exists no more."

This reads like a particularly lurid passage from a science-fiction story, but it is a paraphrased statement, with only the technical phrases simplified, made by one of the foremost astronautical engineers of General Electric's MSVD—Dandridge M. Cole. Behind his prognostication are solid and sober data.

This is one of the many startling ideas that have been advanced by astro-scientists. The USAF is studying a series of Cosmic Military Systems which may become hardware if earth's Cold War someday becomes a Hot War in interplanetary space.

Let us set the stage before we go on.

Let us suppose ourselves in a period of time beyond



THE WEAPONS

PART II

1970. The first moon landings have been accomplished and amid the jumbled lunar wastelands exists a permanent military base—or bases. They fly the Stars and Stripes, or Hammer and Sickle—or both.

The decade's manned flight experiments, from 1960 to 1970, resulted in orbital platforms and giant manned space stations circling earth, with flights to the moon occurring routinely. Fleets of manned maneuverable spaceplanes patrol in cislunar and translunar space.

Advanced nuclear spacecraft follow fast trajectories to Mars, Venus and Mercury, where manned outposts also exist. Deep-space patrol ships are escorting exploratory expeditions to the moons of the outer planets—Jupiter, Saturn, Uranus and Neptune. The first landing on distant Pluto is in the offing.

In short, man has penetrated to the eight other planets and roams throughout the Solar System. Interplanetary commerce has begun. Giant space freighters and rocket-liners ply the spacelanes.

Interplanetary trade and scheduled spaceflights will undoubtedly flourish after 1975. Then, as in the centuries following the discovery of America by Columbus, there will come the era of space empire building.

War for the Solar System

Will that era also bring the bitter wars that marked the exploitation of the New World on earth? Will the New Worlds of space become the interplanetary prizes of the last quarter of the 20th century, and thus convert interplanetary space into a vast battleground?

We cannot answer this somber question today. It is

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PROSPECTS of PEACE

Space age technology can create a world of plenty for all

by NORMAN WEALE

"We should institute an International Space Year (like the IGY) to keep outer space clear of weapons" . . .
Senator Hubert M. Humphrey

Many authorities do not find the prospects bright for mankind to keep his earthly quarrels from lighting the spark of war in space. Yet hope remains. Dr. Glenn Seaborg, Chief of the AEC, stated that, "During the present crisis we are going to ride two horses. We must continue our negotiations with the Russians, and we must at the same time keep our defenses strong. This could, indeed, be the pattern of our international conduct for the next decade."

Hardly a welcome situation, yet we have no choice while the Soviet Union nourishes the Cold War. But assuming an armed peace holds forth in the next ten years, what can be done to bring about a true dis-armed peace before the Space Age door opens wide?

There are several possibilities offered by hard-working men dedicated to the ideals of a united mankind

exploring space in permanent and peaceful partnership.

International Space Year

This idea is sponsored by Senator Hubert Humphrey (D-Minn.). He cites the thought-provoking fact that in the International Geophysical Year from mid-July 1957 to December 1958 some 75 nations—including the USA and USSR—worked in close scientific harmony in many areas. True, the lofting of their Sputnik I and our Explorer I satellites (one of the stated aims of the scientific program) launched the notorious space race. Yet there was far more cooperation behind the scenes than met the eye, particularly at the working level among astronomers, geophysicists, meteorologists and other top-notch scientists of both Russia and America.

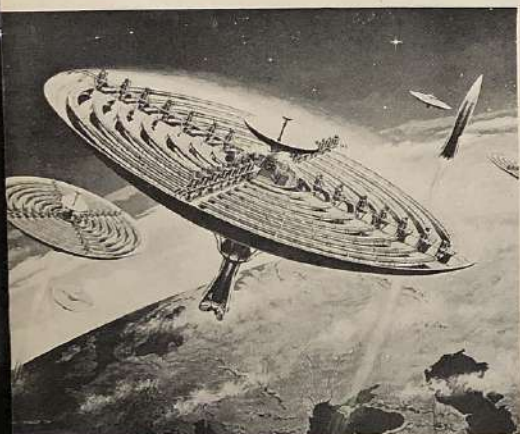
Senator Humphrey boldly suggests an ISY patterned directly after the highly cooperative IGY. Presenting his case before various international scientific bodies such as COSPAR (Committee for Space Research), the IAF (International Astronautical Federation) and the United Nations, the Senator is hopeful that the idea will catch fire in time.

If it does, it will require the USA and USSR to participate in joint launchings of space vehicles and full sharing of the scientific discoveries therefrom. The spirit of working together might then gather enough momentum to become a permanent policy, even after the ISY period officially ended, Humphrey hopes.

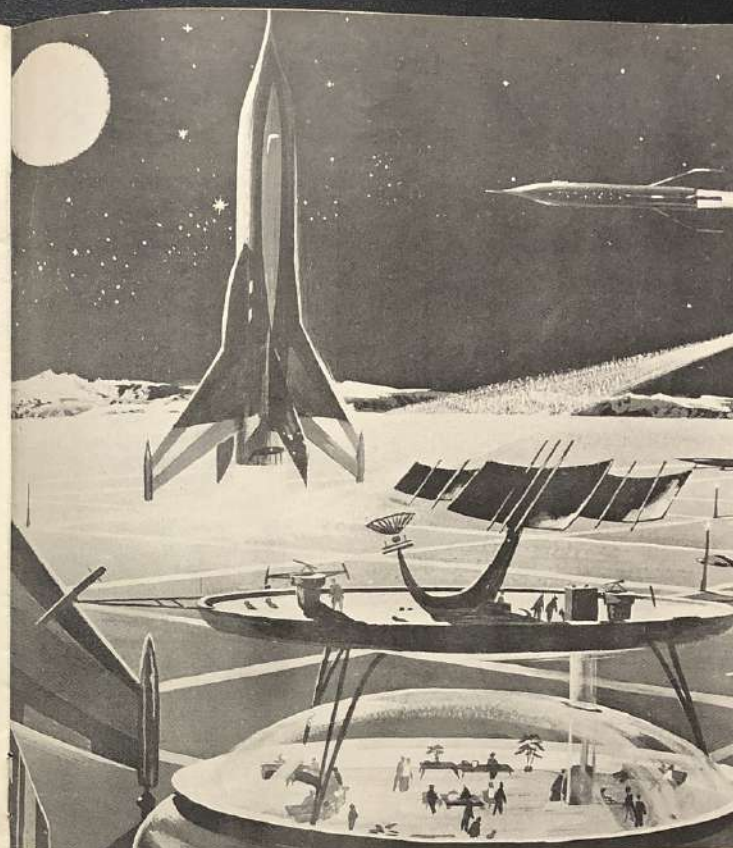
One attractive point in the program is the sharing of costs. Even the Soviets must at times shudder at the thought of the countless billions of rubles it would take for them to conquer space on their own. The dollar and ruble together would ease the burden, and Anglo-Soviet teamwork would also eliminate the wasteful duplication of space hardware now saddling the world's effort as a whole.

Perhaps, if the economy of Russia becomes overstrained as the space race intensifies, the Kremlin will be forced to think seriously about space partnership.

The South Pole regions, too, have seen a paradoxical shining exception to the bitter world rivalry between Democracy and Communism. Without the least opposition, Russia signed the famed Antarctica Treaty which recognizes no territorial claims in the polar continent—and has stuck to it. American explorers in



Algae Farms. Orbiting space stations, taking advantage of strong ultraviolet rays in space, will grow algae for food.



Space Travel. Within twenty years, commercial space travel could be a reality according to today's experts. Giant rocket liners will carry passengers to any point on earth in less than 2 hours.

trouble have been aided by the Soviet polar party, and vice versa, in totally internationalized good will. Scientific data is freely interchanged. One would never suspect that back home, their two governments were interchanging only black looks and harsh words.

One significant point might be drawn from this. Antarctica is a wild, bitter land in which men draw together instinctively to battle the common enemy—nature. Space is even more an Antarctic harshness against which men will have to pit their supreme powers to win out. Perhaps the natural brotherhood that the white continent's hardships brought about on earth will also be distilled from spacemen by the grim challenges of space. Perhaps the astronauts will not think of themselves as Americans or Russians, but as "men against space".

International Science Groups

During the meetings of various international societies, Russian and American scientific fellowship is

genuine. Seldom does politics raise its ugly head. Not that the Soviet space VIPs ever let out any secrets about their space program.

Leonid Sedov, one of the Soviet space program chiefs, confided to an American scientist that "we can get along fine with you Americans. Let us forget what is going on in Washington and Moscow."

For that matter, Nikita Khrushchev himself, in one of his more sober moments, declared that the next war of nuclear weapons could only be started by "lunatics who should be put into strait-jackets. Rockets are terrible, pitiless weapons. Those responsible for the fate of the peoples should seriously think about these things."

Maybe he was paying lip-service only to world opinion, but the reporter who heard the remarks believed Khrushchev was sincere at the moment. This is credible. It would be incredible to believe that any human being had no revulsions against unleashing the atomic Armageddon that hangs menacingly over the

(continued on page 45)

SPACE

MARCH • 50c

WORLD

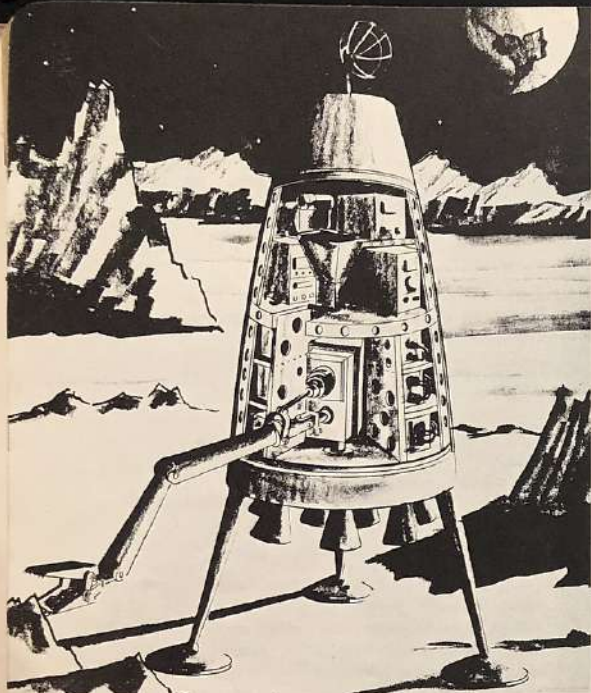
THE MAGAZINE
OF SPACE NEWS

Astronaut's Report:
'HOW WE TRAINED FOR ORBITAL FLIGHT'



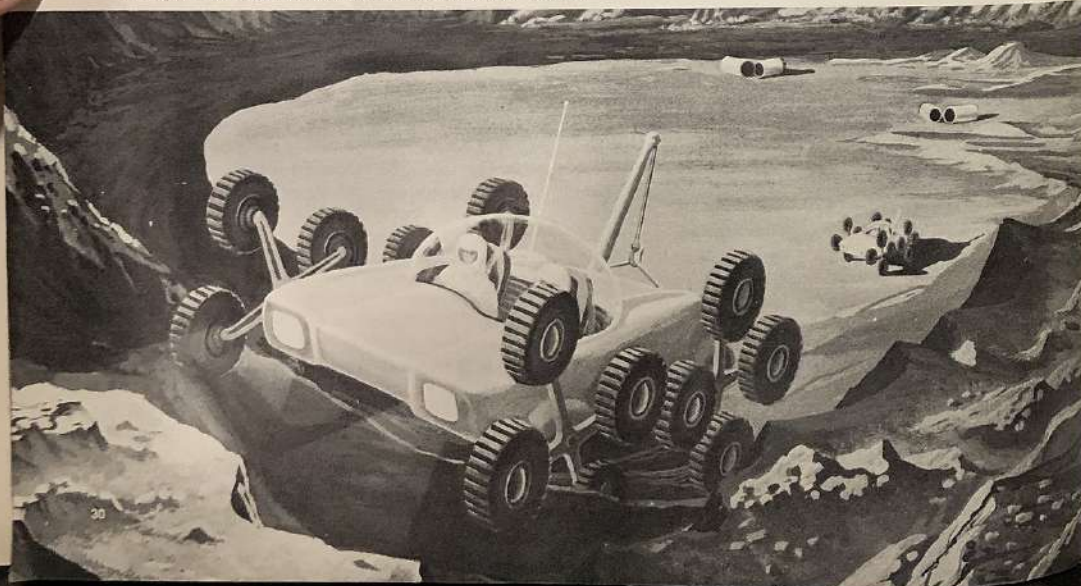
LIEUTENANT COLONEL
JOHN H. GLENN

MOON VEHICLES

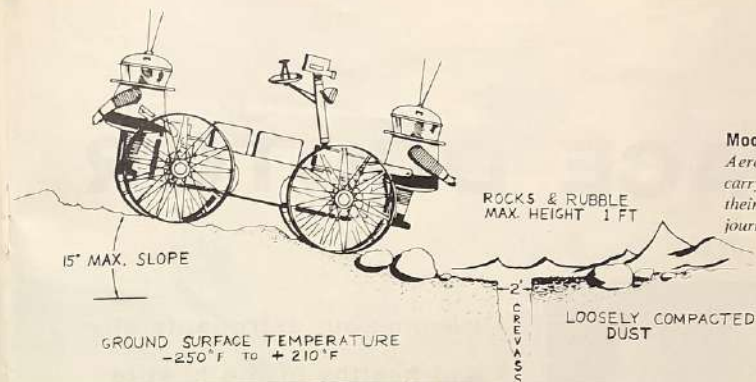


Lunar Mobot. Before men land on the moon, automatic mobots, like this Hughes Aircraft concept, will explore the lunar surface, examine the terrain, and choose ideal sites.

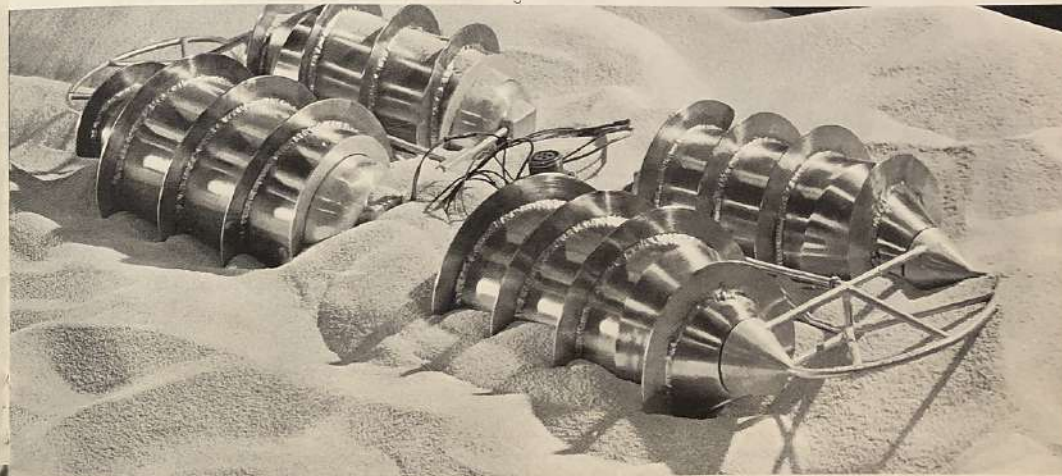
Moon Mobile. After the mobots choose the site and men land on the moon they will use specially designed vehicles to explore the lunar surface. Below is a GE lunar vehicle.



WITH AMERICA'S LUNAR landing program now moving into high gear, research into systems and methods of exploring our closest celestial neighbor has received high priority. Here, on these pages, are some examples of solutions to the problem of moving about on the moon. As far out as any science-fiction dream of only a few years ago, these outlandish vehicles are designed to negotiate any conceivable type of terrain that our lunar explorers might encounter. They come from the drafting boards of engineers of our leading aerospace companies, and represent an effort that is becoming increasingly urgent. Working on data supplied by an army of astronomers who are studying conditions on the moon, the engineers who designed these lunar vehicle models developed prototypes that would facilitate travel over the lunar terrain while protecting the explorers from the harsh conditions that prevail on our natural satellite.



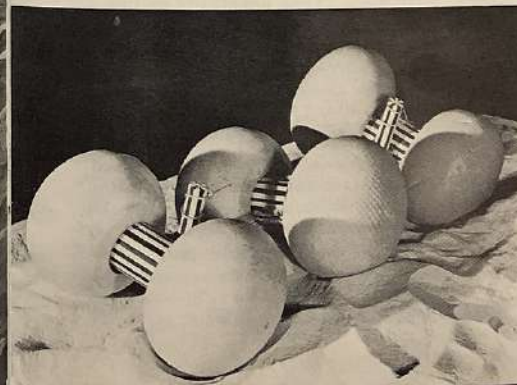
Moon Buggy. This vehicle from Aerojet-General, is designed to carry two lunar prospectors and their survival equipment on short journeys from a central base.



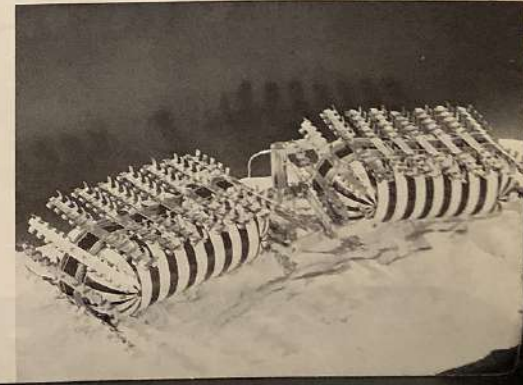
Novel Concept. Laboratory model, above, shows screw-type vehicle configuration that could move over

or through the fine layer of dust that some astronomers believe covers the moon to a depth of thousands of feet.

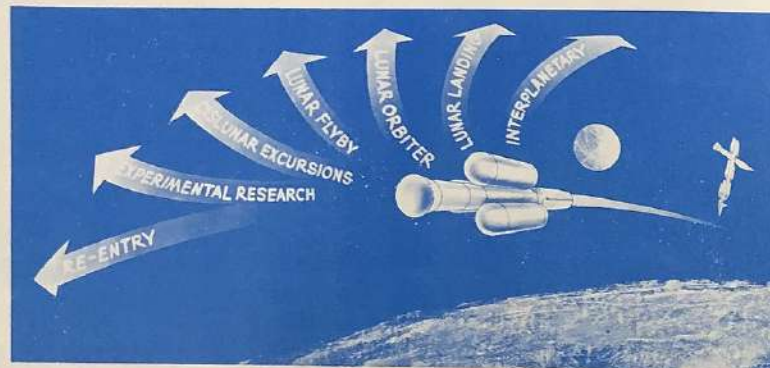
Doughnut Wheel. Huge, soft wheels are a feature of this model of a vehicle type that might rove the moon.



Caterpillar. Carrying its own road, this configuration is another design from General Motors engineers.



LAUNCHING PAD in SPACE



Orbital Rendezvous Base System is designed to launch big manned vehicles to the moon while orbiting earth

by OTTO O. BINDER

It is a day in 1967 and Cape Canaveral is silent. There is no tense countdown to be heard. No launch pad is scorched by sudden orange flames. No rocket thunders into the sky. Yet on this day, America's first manned ship is hurled on its way to the moon. Just where is its launch pad if not on earth?

It is up in space where a small "Cape Canaveral" orbits 300 miles high. It is from here that the moonship rockets away, carrying its crew of three to a rendezvous with destiny.

According to NASA's very latest plans, America's moon conquerors will not leap directly from earth's surface to the lunar terrain. This first trip to another world will be accomplished in two jumps—from earth to orbit, and from that orbit to the moon. The Golovin Committee, which is now pace-setting NASA planning of our overall spaceflight program, has recommended this approach for America's first manned lunar flight.

According to Norman V. Petersen, Chief of the astro sciences group at the Norair Division of Northrop

Corporation, this technique will cut at least two years from previous timetables. His study of this method, called Project ORBS—Orbiting Rendezvous Base System—has just been released.

In brief, the ORBS system calls for using two or more launchings of separate payloads, which will deposit key parts of a compact launch device and a moonship in orbit around earth. When the payload units are brought together in space rendezvous and bolted or welded firmly into one operational structure, an event reminiscent of Cape Canaveral can begin. A countdown will start. At T minus zero, rocket engines ignite and the moonship detaches itself from the launch pad floating in zero-g. A crew of three astronauts then rockets through the black void toward the moon.

But why use such a roundabout 2-step system? The key point is that a lunar-landing vehicle could not depart from Cape Canaveral itself in one direct flight without the use of a giant Nova launch vehicle, which cannot be ready before 1968. The ORBS system, however, can use Saturn type launchers of less power to orbitally unite several payloads into the single Nova-



Canaveral In Space. N. V. Petersen, Northrop scientist, shows model of proposed orbiting launch platform.

weight payload—and several years sooner.

Petersen and his ORBS engineers have based their project on the use of various Saturn launchers that will be available from 1963 on.

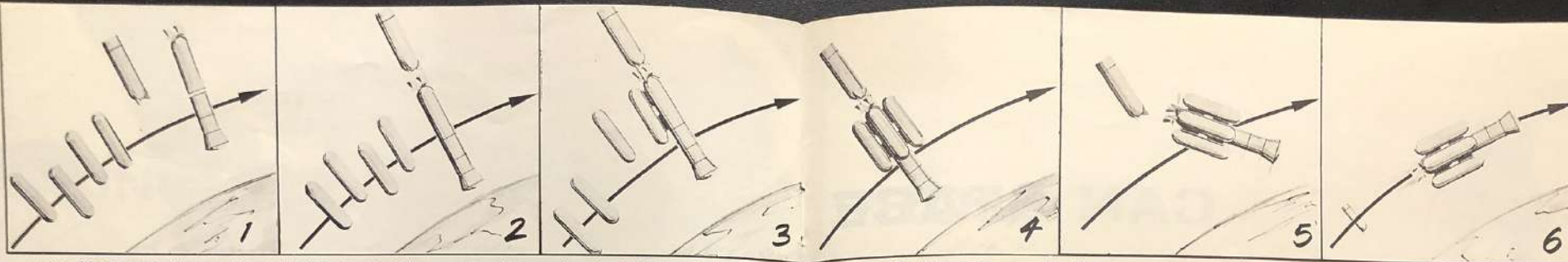
The Boosters

Saturn C-1. The booster of this 3-stage space carrier will be the 8-engine cluster developed by Werner von Braun's team, which in its recent flight-test was a resounding success. However, its payload ability will be relatively low, about 20,000 pounds in low orbit. At least five such Saturn C-1's would be necessary, Petersen estimates, to place material for just the moon launch platform into orbit. Then another 5 or more of the same launchers would be needed to ferry up the fuel tanks and the crew.

Saturn C-3. The Saturn C-2, formerly planned as a 5-stage space truck based on the same booster as the C-1, has apparently been by-passed by NASA officials in favor of leapfrogging to the so-called Saturn C-3. The booster would be entirely different, powered by two of the giant F-1 rocket engines now under top-priority development. Each F-1 is equal in power to the 8-engine C-1 booster, developing the same 1.5 million pounds thrust. Two such F-1's harnessed together as the C-3's booster, plus two hydrogen-fueled upper stages, will triple the performance of the Saturn C-1 and loft some 60,000 pounds into space.

Calculations by Petersen's specialists show that one C-3 and one C-1 launcher from the Saturn stable could then set up the steppingstone space station in the ORBS system. Two more C-3s could bring up the moonship

continued on next page



Assembly Sequence. Component parts of orbiting launch platform are placed into predetermined orbital path where they

rendezvous. Technicians then assemble the component parts into this complete, manned launching facility in space.

This launching technique will save time and money

units and the spacemen.

Saturn C-4. But even the Saturn C-3 may be scrapped by NASA (decision pending) in favor of a booster with four clustered F-1 engines which, combined with upper stages, will be a launch rocket designated the C-4. NASA's propulsion experts expect this mighty missile to heave a heavyweight payload of 200,000 pounds into space. Only two Saturn C-4s would be required to truck the entire segmented ORBS load into orbit.

It does not particularly matter to Petersen what boosters and load carriers NASA finally decides upon. It will not change the basic ORBS concept, merely the number of Saturn-family launchers needed. This

number can range from 2 to 10 vehicles of either Saturn C-1s, C-3s, C-4s, or combinations thereof.

Petersen has built this independence from launch vehicle capacity into his flexible engineering blueprints for the separate modules (basic units) of his Orbiting Rendezvous Base System. The ORBS units or their basic parts can be adapted to any of the Saturn series of space hoisters.

The Modules

The seven vehicle modules called for in the ORBS project are to be of approximately the same size. Each can be segmented to stay within the payload limits of the Saturn C-1. One life-support module and the space base unit will always remain in orbit. The four propellant tanks and the other life-support command module will make up the actual moonship.

The plan is to first earth-launch the life-support vehicle, empty of men but ready for occupancy, fol-

lowed by the space base unit containing radio and other equipment. These two units are to be hooked together as a permanent and reusable orbit launch station. After the four fuel tanks are lofted, the crew comes up last in an engine-equipped craft and fastens the entire assemblage together in preparation for the moon flight.

Rendezvous and Docking

Launching several vehicles into the same general orbit and making them meet without smashing—while whizzing 17,500 mph around earth—may seem an almost insuperable task.

Yet studies by both NASA and Norair experts show it may be less difficult than midair refueling of jets, which has become routine in the air age. Jet bombers and tankers must contend with gusty winds, variable speeds, patches of cloud or sudden fog, and other adverse circumstances as fuel is pumped between the planes.

In space, contact between any two objects can be carried out by well-trained spacemen with utmost precision, undisturbed by variable influences. The laws of gravity and celestial physics are constant, unvarying, and absolutely dependable. It is simply a matter of developing the proper techniques and hardware. Petersen predicts this orbit rendezvous task may in time be as simple as parking a car.

The launching of the seven modules, each a week apart, will be done with precision from Cape Canaveral. The chosen orbit will be close to circular some 300 miles high, at an inclination of 32 degrees to the equator. The module components, when injected into orbit, will be about 10 miles apart in a pattern slightly above and below a focal point in space so that all units can be most easily brought together.

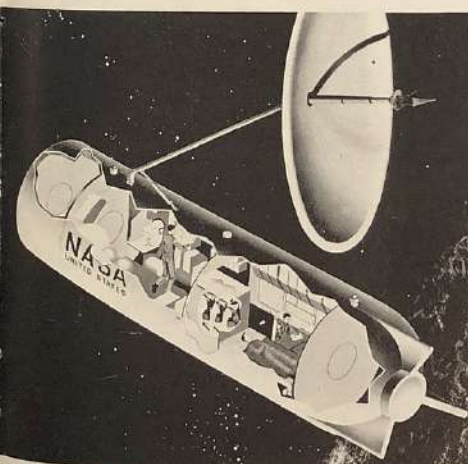
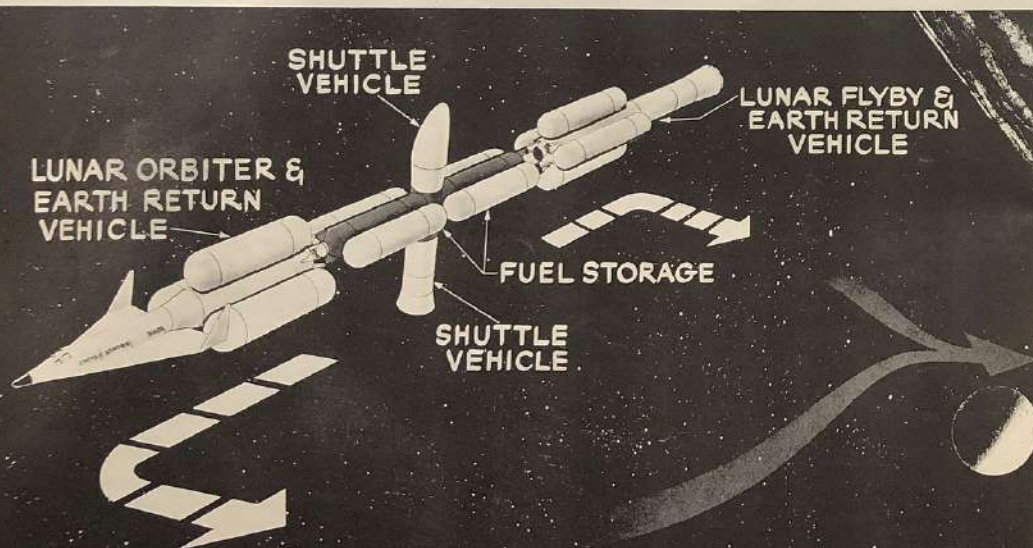
The six unmanned portions of the prefabricated structure must first successfully slip into the right orbital slots before the final craft's crew is rocketed up to hook it all together. As their initial operation, the spacemen in the command module will first use low-power guide rockets to sidle up to the empty space base vehicle.

Docking, or the final coupling of any two of the ORBS components, will be the most delicate maneuver. Several systems have been proposed. The simplest is for the crew to extend a long rod from their craft and carefully aim it to enter an aperture in the other vehicle. The telescoping rod absorbs the initial shock of the contact, then stiffens and prevents the two hulls from banging together. Once firmly hooked between the two craft, the rod is retracted under power, drawing the two wide flat ends of the modules flush.

At that juncture, an airlock is unsealed between the two craft, and the crew can enter the base station and use all its command instrumentation. With these remote controls, the astronauts can fire the guide rockets of the other five orbiters, bringing them together in the pre-planned functional pattern to form a single structure.

Petersen has based his ORBS project on a timetable of 6 to 10 days for assembly operations and 14 days for the lunar landing trip back and forth, or a total of 20 to 24 days in space for three men.

(continued on page 53)



Base Module. Basic component, above, can be expanded (l.) into complex manned space station in artist's drawing.

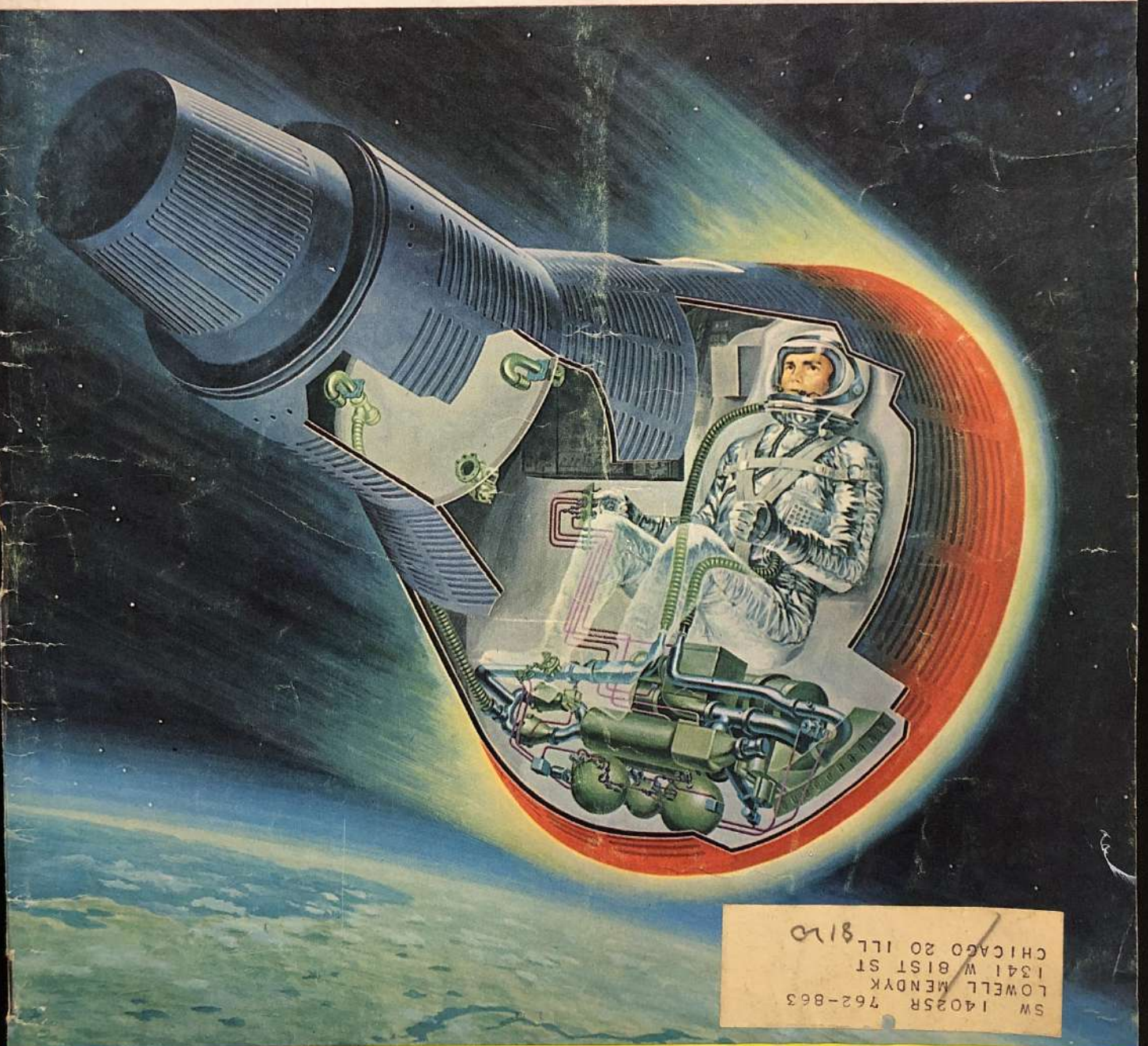
SPACE

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Our next step: 18 TIMES AROUND THE EARTH



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SPECIAL JETS & ROCKETS SECTION

- U-2 Pilots: The lonely heroes
- Are manned Jet Bombers obsolete?
- The Frogmen who save our Astronauts

3 MEN to the MOON



On the way. Three-man Apollo vehicle, as envisioned by GE's Roy Scarfo, will be designed for initial circumnavigation of moon and, finally, landing a three-man party on the lunar surface and then return them safely back to earth after they have accomplished their exploratory mission.

Multi-mission vehicle. In this concept (right) by Republic Aviation engineers, the Apollo craft will be fitted with retractable wings that will be utilized after the spacecraft re-enters earth's atmosphere. Wings would provide aerodynamic lifting surfaces to help ease the space vehicle to earth.

With its booster and space vehicle now on the drawing boards, Project Apollo moves closer to realization

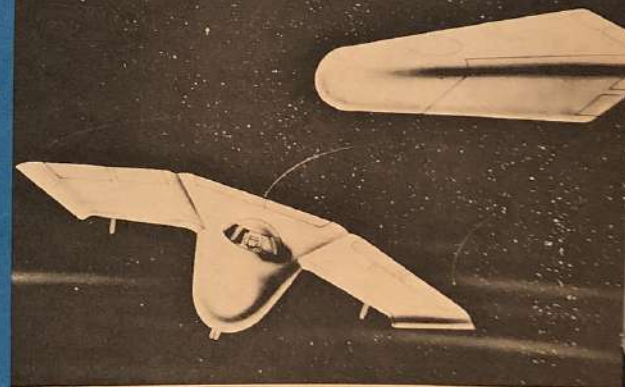
by ERNEST HAUSSMAN

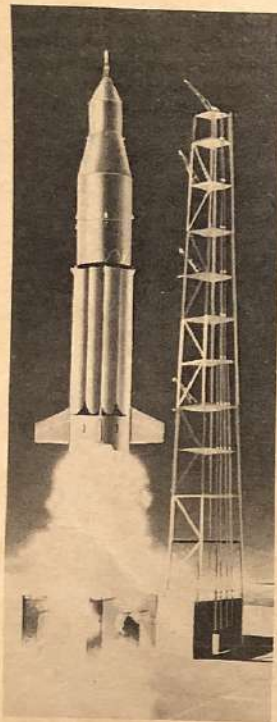
In 1961 and 1962, we have seen only the opening innings of the interplanetary ballgame. The triple play of Shepard to Grissom to Glenn chalked up America's first orbital spaceflight in the Mercury Program. But Mercury to Gemini to Apollo will be the triple play leading to complex spacecraft assembled by orbital rendezvous techniques. And finally, Apollo-A (earth-orbit) to Apollo-B (circumlunar) to Apollo-C (moon-landing) will drive a ship and three men to the moon.

These are the steps that lie ahead in the development of spaceflight. We will achieve our goal in this decade—and place human footprints in the lunar dust.

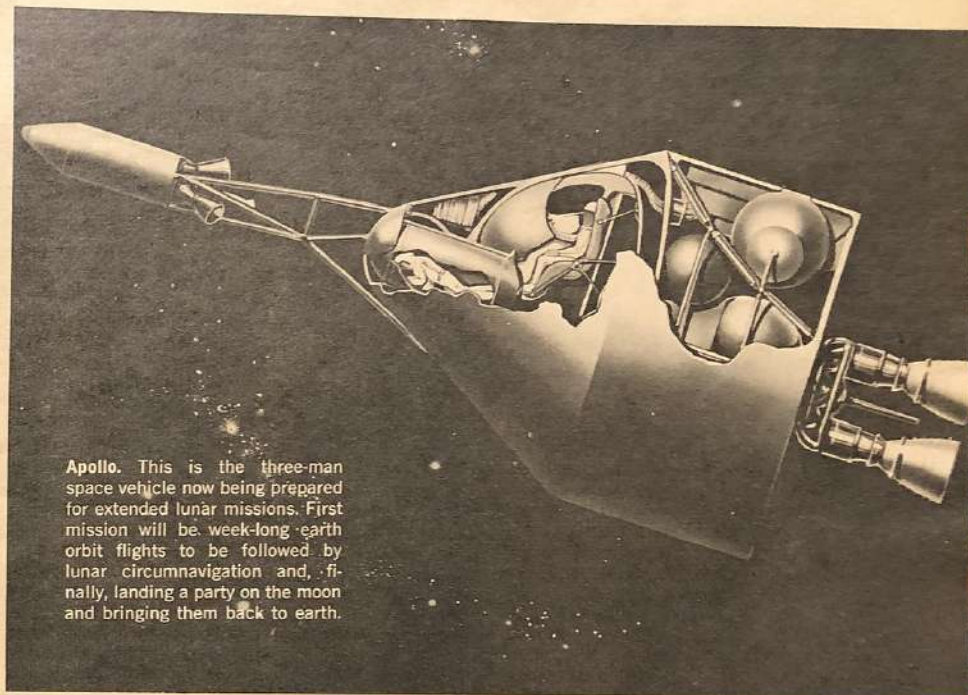
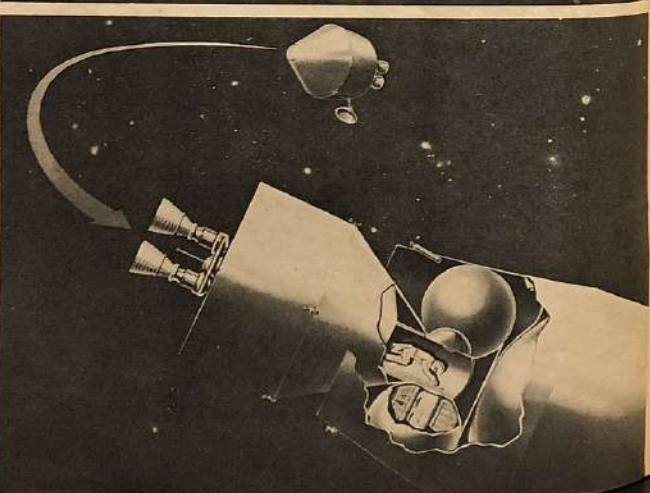
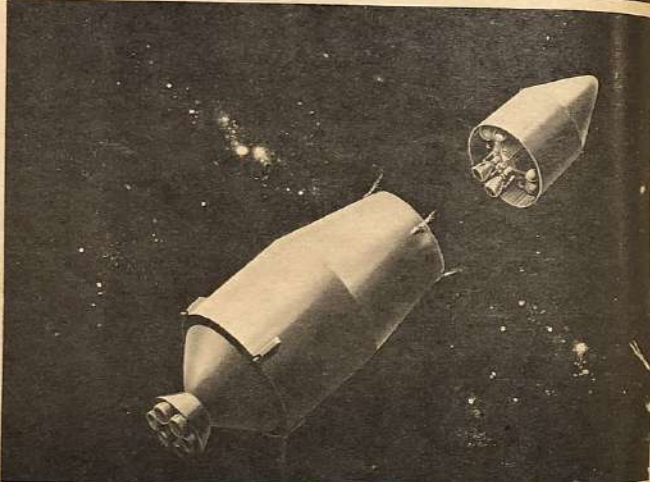
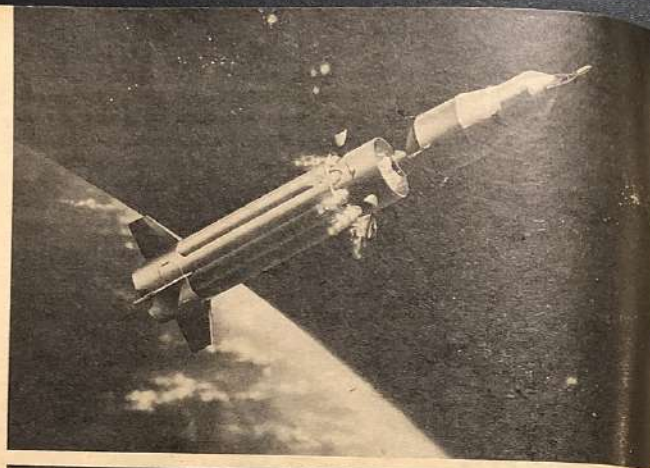
The Mercury Program

Aside from preliminary flights, the Mercury Program began in mid-1961 with the suborbital flights of Alan Shepard and Gus Grissom and February 1962 saw a big step ahead with the





Saturn launch. Sequence of drawings on this page show trial steps of Apollo program. Drawing above shows Saturn C-1 vehicle lifting from Canaveral pad. Top right, 2nd stage ignites after booster burns out. Middle panel depicts payload separation, before space rendezvous; bottom panel shows individual pay loads, lofted by Saturn boosters, joined together to form the actual Lunar landing vehicle.



Apollo. This is the three-man space vehicle now being prepared for extended lunar missions. First mission will be week-long earth orbit flights to be followed by lunar circumnavigation and, finally, landing a party on the moon and bringing them back to earth.

3 MEN TO THE MOON continued

KENNEDY HAS SET LUNAR LANDING TARGET DATE

3-orbit flight of John Glenn.

The rest of the Mercury schedule calls for further 3-orbit flights about 60 days apart, with Walter Schirra and Malcolm Carpenter next in line. Either in late 1962 or early 1963, the acme of solo Mercury journeys will enter history—the 18-orbit mission. A series of these may extend through 1963 in order to gather manned flight experience and to lay the groundwork for a much more ambitious undertaking by our astronauts.

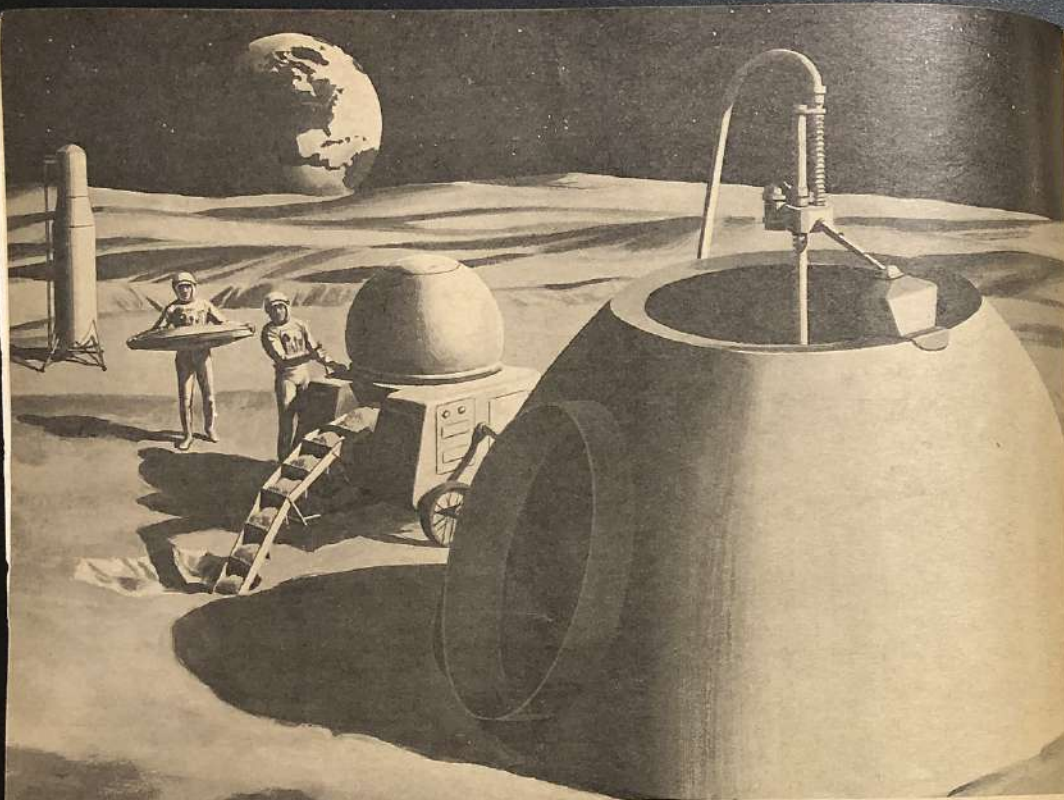
The Gemini Program

The one-man Mercury flights will end when the two-man Gemini flights phase in about early 1964. The Gemini will be an enlarged version of the Mercury Capsule, one foot wider at the broad end and several

feet taller. This will increase the interior space by 50% so that two men can ride side by side.

This is the Gemini-A, according to NASA specifications, which are in a state of flux. All data, naturally, is tentative. Gemini-A will weigh approximately 4500 pounds at launch and have a recovery weight of 2850 pounds, compared with 4000 and 2200 pounds for the Mercury.

NASA points out that, unlike its predecessor, the Gemini is not a capsule but a spacecraft. This term is valid because we currently plan to fit adjustable flaps around Gemini's base to provide a certain amount of aerodynamic lift (as airplane wings do). This will give the two-astronaut crew an ability to maneuver that the Mercury astronauts never had. It will allow control of



3 MEN TO THE MOON continued

The moon will serve as base for further space exploration

the re-entry pattern through the air and also increase the chances of landing close to the waiting recovery forces.

In the recovery's end phase, the double-weight Gemini will require either two 63-foot Mercury parachutes, or one big 105-foot chute. However, NASA is researching the Parasev—for Paraglider Separable Vehicle—which is a flexible glider device that would unfold during aerial re-entry. The Parasev may prove superior to a parachute for easing down the Gemini. Also, a parawing (triangular kite) device will be packed within the craft as an emergency descent system for the astronaut team. This will give the two Gemini flyers an escape-system from their craft after re-entry, something that the Mercury astronaut did not have.

The Gemini's missions will be successively longer—trips of one day, then three days, finally a week. But another major mission will make the first experiments in achieving rendezvous between two orbiting vehicles. This new task will require a Gemini-B weighing about 6000 pounds at lift-off. The extra payload will include an inboard rocket engine with re-start ability in space, so the crew can maneuver their craft and "dock" with another payload in orbit.

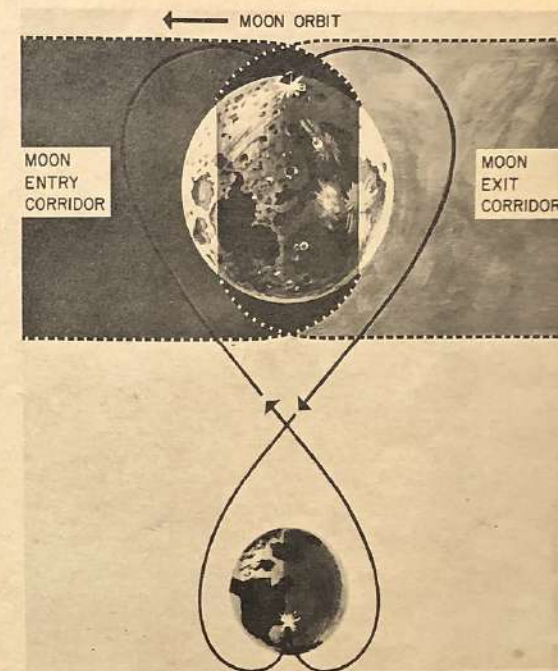
Gemini's booster will be the Titan II, whose storable propellants allow reduced countdowns of less than 3 minutes for the military missiles. Civilian countdowns need not be that hurried, particularly with human lives to be considered, but the countdown may still be as short as one hour. Titan II's thrust of 530,000 pounds—

(continued on page 52)

Exploration. Primary purpose of manned lunar expedition will be to collect samples of terrain and find most suitable spot for constructing a permanent base. First explorers will also search for life forms that might exist on the moon.

Route. Two space lanes, each a hundred miles wide, have already been plotted as corridors for all lunar vehicles. Sketch, right, shows how spacecraft will enter a corridor for a moon landing and path it will take leaving the moon for return trip to earth. Moon entry corridors will provide most direct earth-to-moon paths and will be routed to reduce radiation dangers.

Return. Drawing, below, shows steps lunar vehicle will take on return trip to earth. After re-entry into the atmosphere, parachutes will ease the vehicle to pre-selected landing site on earth.



THE DOCTORS' STRANGE NEW PROBLEM

HOW TO KEEP MEN HAPPY IN OUTER SPACE

by DR. JAMES N. WAGGONER

When men take off on month-long journeys to the planets, boredom and fatigue will be big obstacles



The first three astronauts who land on the moon may well have spent their last weeks on Earth in an isolation suite of a hospital trying to give each other measles or the flu.

Isolating the astronauts in a sterile atmosphere so that they can exchange diseases and promptly be cured is illustrative of the painstaking care, thought and imagination that is now being put into the project to put men in space.

Before the trip to the hospital where the space travelers will mix their "germ cocktail," however, exhaustive medical histories will have been taken. They will have been immunized against all diseases possible, and their general health will, of course, have been good for quite some time.

There are reasons for these precautions: *There can be little surgery in the weightlessness of outer space.* If an astronaut were unlucky enough to suffer an unpredictable attack of appendicitis, it would probably be unwise to attempt "amateur surgery" such as that performed by a Navy medical corpsman in a submerged submarine during World War II.

On a short space voyage, say to the moon and back, the stricken astronaut would be shot full of an anti-

biotic such as penicillin to keep the infection under control until the voyage was over. On a longer trip, however, it is logical to assume several specially trained persons will be present. Among these will undoubtedly be a flight surgeon, capable of treating whatever ailments may occur in the best medical manner.

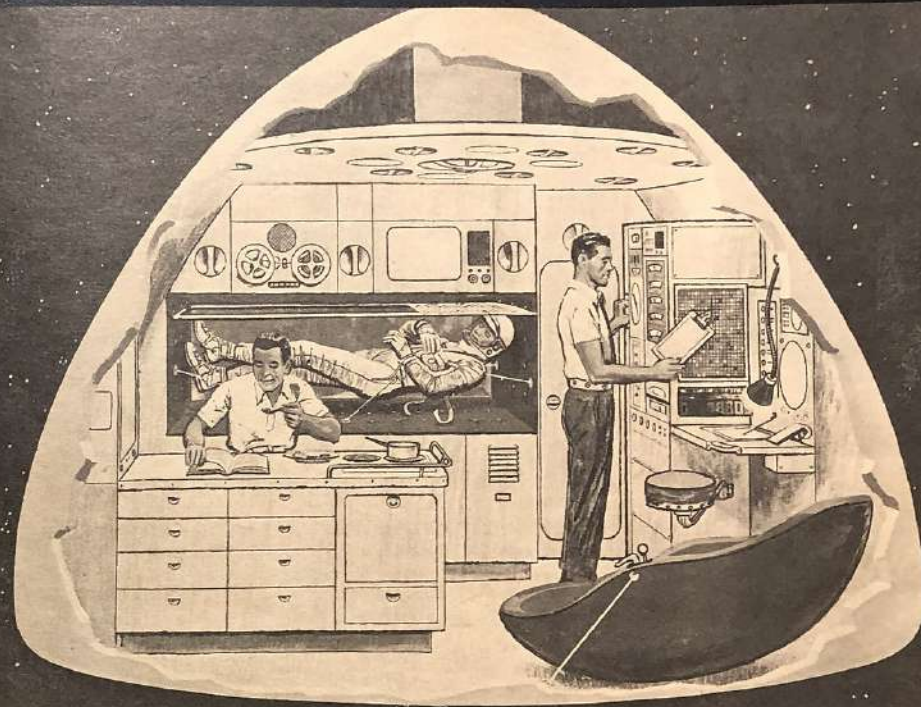
Contrary to popular opinion, an astronaut will not have his appendix removed as a precaution. Surgeons don't like to disturb healthy organs if there is absolutely no history of prior symptoms.

As far as a cold in the head is concerned, the treatment is the same as on Earth. Blow your nose, drink water and wait until it goes away.

Moon Microbes

Not only will astronauts landing on the moon be as germ-free as medical science can make them, but their space vehicle and clothing will be antiseptic, too. *They will have to don specially sterilized space suits carried in an isolated sterile compartment of the vehicle before they climb down to the moon's surface.*

Already scientists are worrying about what might happen if the exploratory vehicles that precede the manned landing on the moon are contaminated.



Three-man mission. On extended space flights, crew will be assigned complex duties to help ward off boredom.

We feel sure that there is no human life on the moon, but what happens if the first astronauts find some form of simple microscopic life? *Was it there before Earth made its first contact, or afterwards?*

Furthermore, the analysis of the uncontaminated minerals found on the lunar surface may well provide new knowledge of the origin of the universe and even life itself. This will not be possible if we contaminate the moon when we land.

We already know that certain strains of bacteria can live in the near-vacuum atmosphere of the moon. If once introduced, they would reproduce so fast they could cover the entire surface of the moon in a matter of three days. This would obliterate forever our opportunity to gain scientific knowledge.

Scientists are not limiting their planning for space voyages to conditioning astronauts before they lift-off and decontaminating them before they land. Utmost concern is being given to their physical and mental well-being during a space voyage. And this is not mere pampering of our newest national heroes.

Conclusive tests conducted at the Air Force's School of Aerospace Medicine and at other laboratories show that the isolation and other factors of space travel can

have a harrowing effect on an astronaut.

Thus, all efforts are being directed toward creating an environment within the space vehicle that is as close as possible to that which the astronauts were accustomed to on Earth. Only if as many mental and physical discomforts and distractions as possible are removed, can the crew of a space vehicle perform their duties with top efficiency.

Fireside in Space

We cannot quite duplicate all the comforts of the fireside in a weightless condition, but we can produce "shirt sleeve comfort" as far as pressurization, temperature and humidity are concerned.

The air the crew breathes will be a mixture of nitrogen and oxygen such as on Earth. It will not be necessary to maintain the total pressure of all gases at the same level as that found at sea level, even for extended space flights. But the oxygen level will need to remain at an Earth equivalent to assure the human's ability to perform not only adequately, but to be capable of making on-the-spot decisions vitally necessary for a successful space flight. And the temperature and humidity will be kept well within the "comfort zone" to insure

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SPACE WORLD

The Magazine of Space News

AUGUST 50c
VOL. 1, NO. 9

**EXCLUSIVE - A Russian scientist reports on
THE SOVIET MAN IN SPACE**

**A list of every rocket shoot ever made
WILLY LEY'S COMPLETE ASTRO-CALENDAR**



Alan Shepard

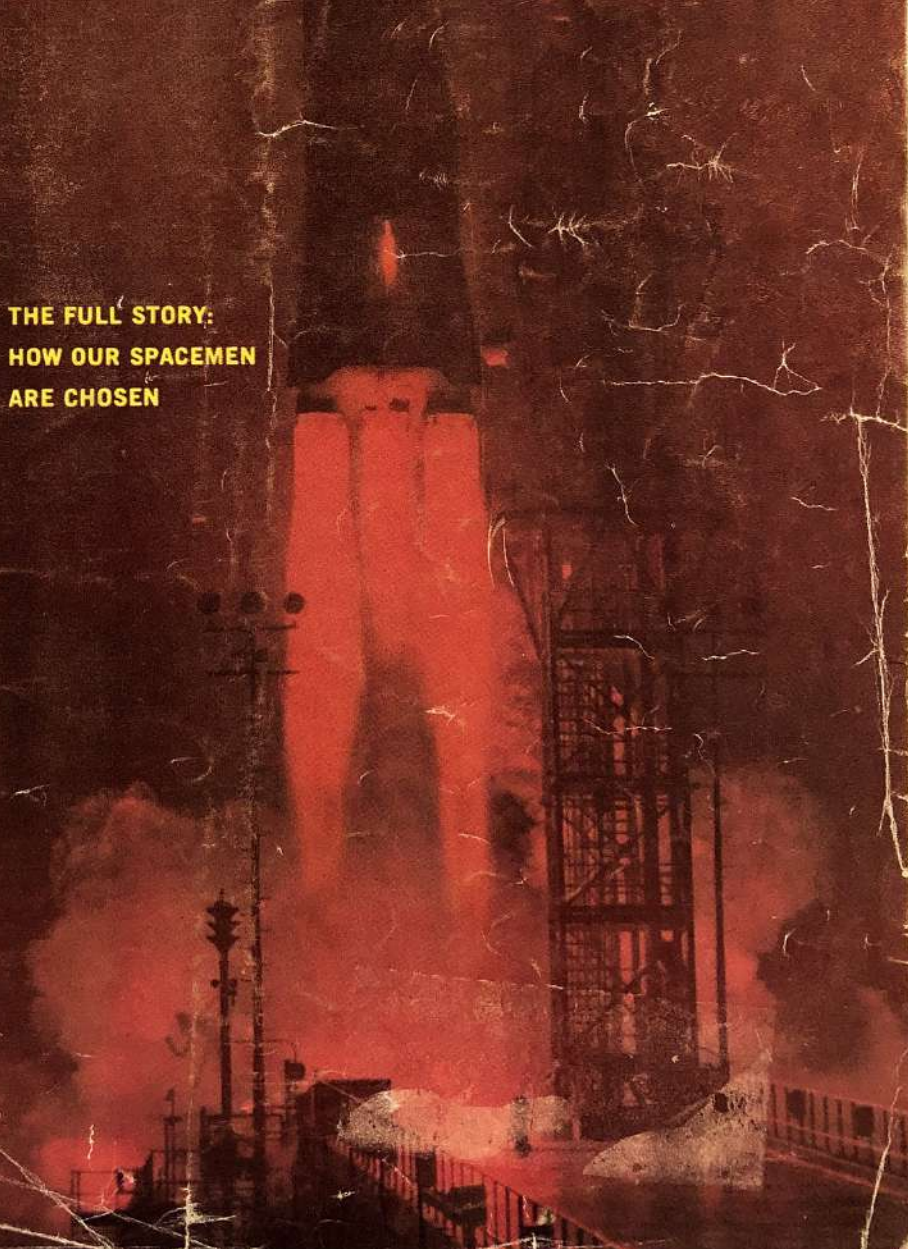


Virgil Grissom



John Glenn

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On the cover: These three men—John Glenn, Virgil Grissom and Alan Shepard—were chosen from among thousands to be the first Americans into space. For the story on how the choice was made, turn to page 16.

SPACE WORLD

The magazine of space news • August 1961

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First Step. Sputnik 1, first man-made satellite.

SOVIET MAN IN SPACE

by INNA YAVORSKAYA

AT 2 a.m. on April 12, the temperature at Tyura Tam was in the low 40s when Yuri Gagarin, a young major in our Soviet Air Force, was roused by an attending physician. He had been asleep since early evening. Perhaps his heart beat a little faster than usual as he did his morning calisthenics. The winds were mild at five to ten miles per hour and only a few scattered clouds obscured the newly risen moon.

A storm center was developing over the Black Sea, some 1000 miles due west, but the meteorologists decided that it would not interfere with the morning's task.

By 6 a.m., Gagarin had undergone a thorough medical check and had eaten a low-roughage breakfast. Now began the final steps of his great adventure.

Technicians helped the young cosmonaut don his tightfitting pressure suit, after electrodes that would measure his heart-beat, temperature, respiration rate, etc., had been attached to his skin. Outside, as the last stars faded from the skies of southern Russia, a feverish activity centered around the huge rocket that stood on its launching pad. The big tanks were filled with liquid oxygen and refined kerosene, and engineers and technicians checked out the numerous pieces of delicate equipment that make up the heart of the rocket.

About two hours before launching, Gagarin walked

to the rocket service tower, his white plastic helmet with clear visor fastened to his dark-blue flying uniform. Gagarin shook hands with his comrades and stepped into the elevator. In answer to the excited waves of the technicians and engineers that swarmed about the launching pad, he held both hands over his head for a moment. The elevator carried him swiftly to the crown of the rocket. There, atop the tapered cylinder of the booster which towered some 100 feet above the ground, Gagarin stepped inside *korabl sputnik XI*, named *Vostok* (East), in honor of the first human passenger.

At 9 a.m. (Moscow time) the huge service tower moved away from the rocket on its tracks. Inside the cabin, a television camera pointed at Gagarin was activated. Lying on his back, in a form-fitting couch, his knees pulled up, Gagarin reported that he was ready.

Seven minutes later, the huge engines flamed into life. The *Vostok* lifted off the pad suspended on a curtain of flame. It hovered for a second, then gained speed and screamed upward. Inside the cabin, the crushing forces of acceleration squeezed Gagarin against his couch. As each booster ignited in turn, hurling the space ship higher and faster, Gagarin felt the heavy weight of acceleration.

At 50,000 feet, the huge ship began to tilt over
(continued on page 14)



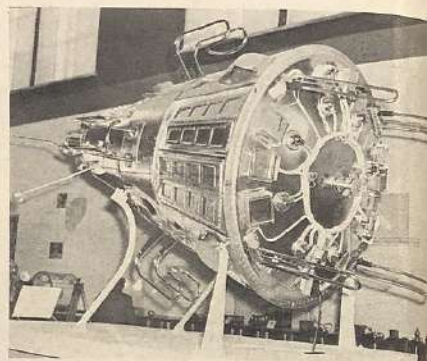
FIRST MAN INTO SPACE
On the morning of April 12, Yuri Gagarin mounted a capsule perched in the nose of a giant booster, orbited the earth, and returned successfully.



Second Step. Model of Sputnik II, Russia's second satellite, was put on display after the space vehicle was launched on November 3, 1957.



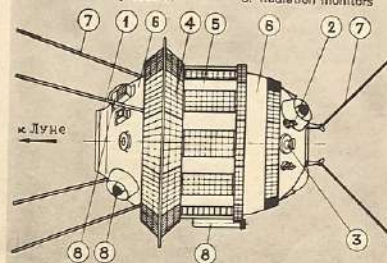
Passenger. The dog Laika, above, was placed into orbit aboard Sputnik II to test her reactions to weightlessness.



Third Step. Sputnik III, above, launched by Russians on May 15, 1958, was larger than current Mercury capsule.



1. Illuminator for camera
2. Orientation system motor
3. Solar monitor
4. Sun battery section
5. Thermo regulators
6. Thermo screens
7. Antennas
8. Radiation monitors



Fourth Step. Lunik III, which took first pictures of far side of moon, above, proved out Russian guidance system.



Triumphant Return. Major Yuri Gagarin returns after completing first manned orbital flight around the world aboard Russia's Sputnik X1.

Rocket launcher, life-support cabin and recovery

towards the northeast. Gagarin had time to glance out of his viewing port. "I see the earth in haze," he reported. "My, it is beautiful."

In five minutes, the last booster had ignited to push the capsule on the final leg into orbit. Separating from the space cabin, the empty rocket casing trailed behind as the *Vostok* passed over the Siberian land mass.

Eighty-nine minutes after launching, Yuri Gagarin stepped out of the *Vostok* in the pre-selected landing area. Man had ventured into space and had returned successfully. Soviet scientists and engineers had forged the path to the stars. For the first time, a man's eyes had seen the curvature of the earth. For the first time, a man had experienced weightlessness for more than a few seconds. An expectant world hailed the news and the name Yuri Gagarin will go down in history.

But this epochal scientific achievement was merely the culmination of work and effort that had begun years before. It was like the crown of an iceberg whose huge mass is hidden beneath the waters.

How, then, did our Soviet scientists accomplish this

feat? What were the steps that preceded Major Gagarin's flight into space?

Three major problems had to be solved before manned flight into space could be undertaken—developing rockets for cosmonauts capable of overcoming the earth's gravity, insuring the safety of human travel in space, and arranging for man's safe return to earth.

The launching of space rockets and satellites—especially of the Soviet's 5-ton spacecraft of March 9 and 25, 1961—made it abundantly clear that the first of these problems had been solved.

Much of the research our scientists have been carrying on with these vehicles was directed towards the final solution of the other two problems.

Taking the second one, how was the safety of the cosmonauts to be insured? The human organism is rather delicate in space terms and is adapted for living nowhere except in the earth-bound environment. To sustain man's life-cycle functions beyond his planet, an artificial atmosphere with a definite amount of oxygen, a

system are the necessities of manned space flight

definite pressure and a proper temperature is required.

Doctors know that at an altitude of 8 kilometers (5 miles), a human being quickly loses consciousness. At the height of 15 km. (9½m.) he faints within 15 seconds. At the height of 19-20 km. (12 mi.) the air pressure is so low that his blood boils in his veins, even with an oxygen supply provided.

The pressure at the heights of space traversed by satellites is practically zero, and oxygen is non-existent. This means that the interplanetary medium cannot support human life for even a fraction of a second. So, the cosmonaut in space flight must be accommodated in a sealed cabin with an interior environment simulating earth's. It is this kind of air-tight capsule that carried the dog Laika, the first living creature to have traveled into space, in Soviet Sputnik II, Nov. 1957. Similar cabins were installed in our spaceship satellites, starting with Spacecraft I [Sputnik IV] on May 15, 1960, followed by Spacecraft II, III, IV and V [excluding Sputnik VII and the Venus Probe]. The cabins contained a system for air re-oxygenation, carbon dioxide

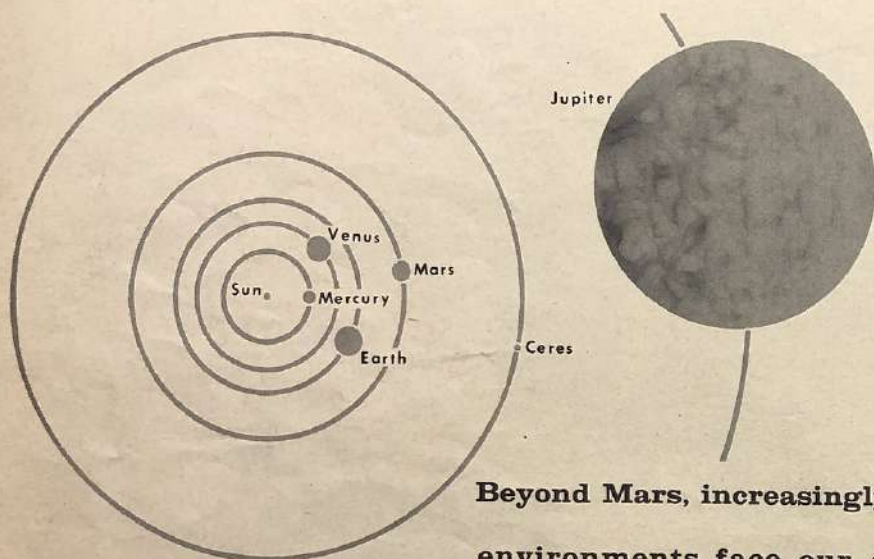
disposal, and heat regulation.

It is this sort of cabin that was designed for man to make his maiden flight into space. What made the information transmitted from the Sputnik spaceships most valuable is that the temperature and pressure of the air was maintained within the prescribed limits up to a month. Some thought must be given also—in manned space flight—to the possibility of sudden decompression from a meteorite impact, however rare this danger may turn out to be. For that reason, the cosmonaut has to use a special space suit designed to make up for any loss of pressure if the cabin ruptures.

Another serious problem that had to be overcome was the effect inevitably produced by the long accelerations and decelerations of the spaceship's take-off and landing. The spaceship's steady speed, however great, has no effect on the organism. It is only a change of speed, whether becoming slower or faster, that creates an overload—an additional force which, depending on the magnitude of acceleration or deceleration, may be several times as great as man's normal weight.

(continued on page 54)

EXTRATERRESTRIAL



Beyond Mars, increasingly hostile environments face our colonists

by OTTO O. BINDER

When we have finally succeeded in establishing permanent manned outposts on both the moon and Mars, where will our colonists next find planetary abodes?

The answer, based on our present knowledge, is a toss-up. Venus and Mercury seem most likely to be visited early by manned expeditions since these planets are comparatively near earth. But the asteroids beyond Mars and even the moons of Jupiter could become targets for exploration and settlement at about the same time.

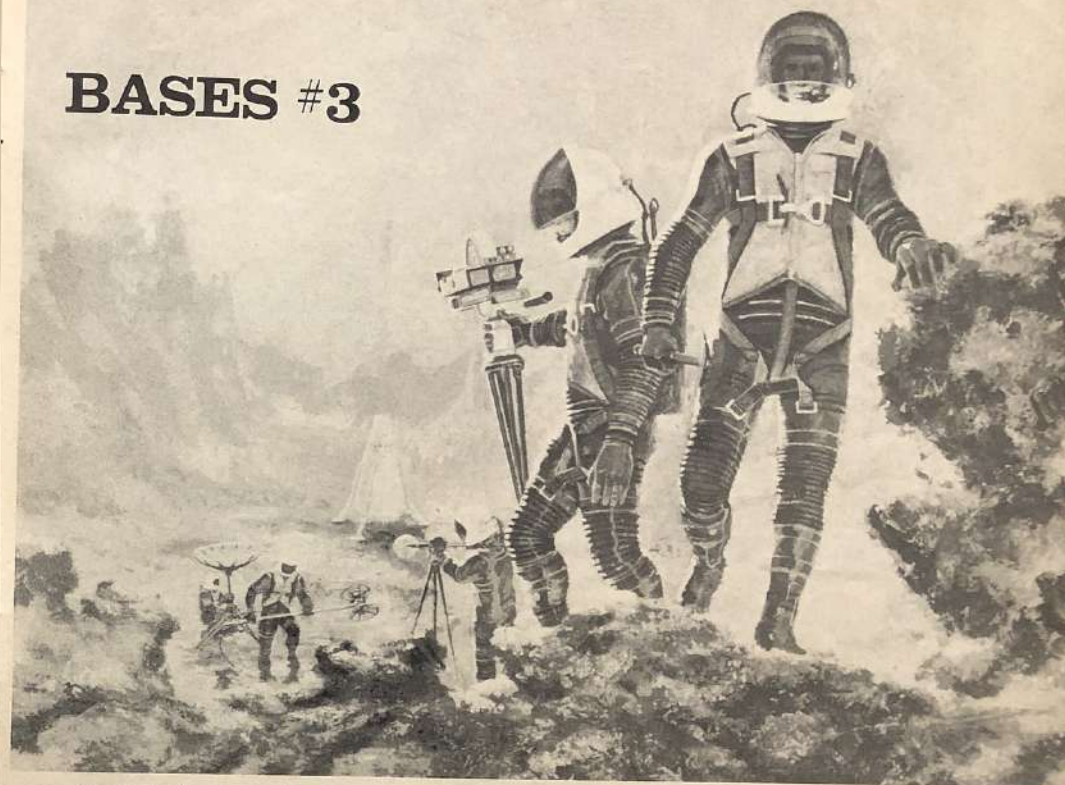
After the moon and Mars, none of the solar system bodies has any particular advantage over the other. Which will prove suitable or desirable as colonies will depend on factors presently unknown. Considering heavenly bodies in the order of their nearness to earth, our first subject is Venus.

Venus is three worlds — in theory at least. Because its surface is always shrouded from telescopic view,

astronomical opinion is more divided about conditions on Venus than on any other planet or body. One camp believes that Venus is a bone-dry desert world. Another group claims Venus is covered by water from pole to pole. These Wets and Drys are challenged by a third group who subscribe to a theory prevalent in the last century—that Venus is a dry-and-wet world similar to earth, perhaps with comparable environment and life forms, both plant and animal.

Scientists have been able to examine (with the spectroscope) only the top layer of clouds that surround Venus. They find this portion of its atmosphere to consist mainly of carbon dioxide with traces of nitrogen, oxygen and water vapor. Most authorities concede that spectroscopic examination reveals nothing of the lower air of Venus which may be oxygenated and moist. British expert Felix Godwin says, "If this is the case, there is no reason why life of sorts should not exist on Venus." Dr. Heinz Haber speculates that a sort of

BASES #3



Asteroid Landing. Artist's drawing shows a landing party on an asteroid in orbit between Mars and Jupiter.

aerial "plankton", preyed upon by flying creatures, may float in the heavy Venusian atmosphere.

Housing

Venus is the earth's "sister" in general size and surface gravity. The Venus day however, is generally believed to be weeks long. The surface temperature cannot be much less than the boiling point of water and is perhaps higher. The sea-level pressure of its massive atmosphere might make earth people uncomfortable and force them to wear anti-pressure suits.

This greater-than-earth air pressure would mean that any plastic housing filled with earth-thin air, and not anchored down, would float upward like a hydrogen-filled balloon. Godwin suggests that if Venusian air contains suffocating amounts of carbon dioxide and poisonous fumes such as carbon monoxide, the doorway into the colony would not be an air-lock but a "water-lock". Colonists arriving on Venus would have

to swim through a water tank which keeps the outer gases from seeping into the interior.

We could cope with conditions on Venus with our present environment technology only if both the Wets and Drys are wrong and the Wet-Drys are right.

If Venus is totally arid, as the Drys maintain, the problems of colonization would be enormous. And if, as the Wets think, it is one tempestuous sea from pole to pole, it might also be shunned by the hardiest of settlers.

Time, and Venus probe investigations, will probably tell the tale although there is a possibility that probe borne radar, ultra-violet and infra-red scanners will be unable to pierce the Venus veil to examine the surface. In this case, we may have to wait until payloads can be soft-landed on the Venusian surface to find out if mankind has gained a colony—or lost a world.

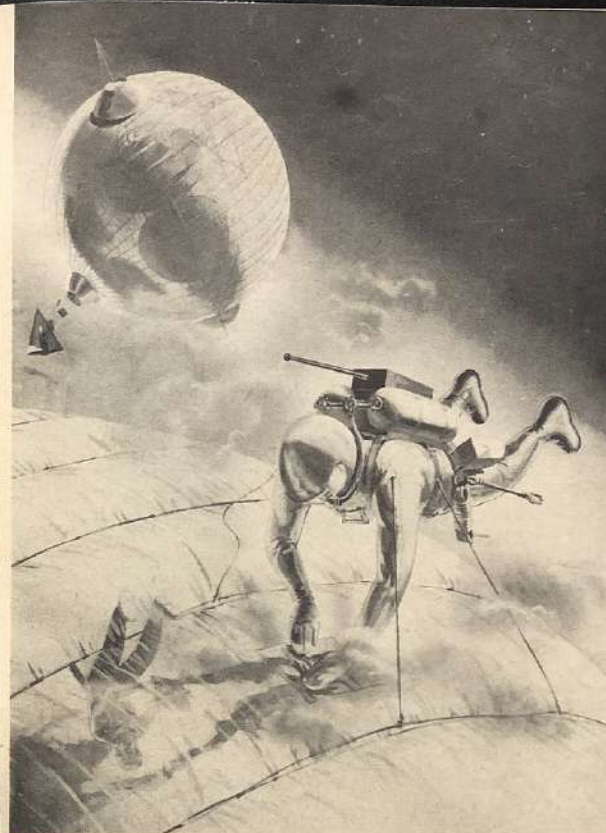
Colonists looking for a place to spend years or to remain permanently may shun Mercury for a long time.

(continued on page 46)

INFLATABLE SPACE VEHICLES

by ROBERT GRANVILLE

An examination of the new family of satellites that began with Echo I



Inflatables. Artist's concept, left, shows large earth-orbiting balloons that would contain controlled atmosphere enabling technicians inside to work without wearing space suits. A. Antuchin, RCA engineer, above, demonstrates model of an inflatable antenna designed for satellite telemetry.

If anyone had suggested 10 years ago that "balloons" could have a use in airless space as substitutes for metallic vehicles, he would have seemed as light-headed as a helium-filled balloon.

But after August 12, 1960, his suggestion would have won him acclaim as a space oracle.

On that date, an aluminized Mylar plastic sphere 100 feet in diameter (Echo I) became the first American satellite visible to the naked eye, and excited millions watched this starlike radio-relay device meander among the constellations.

Before Echo I had made a few dozen revolutions around earth, teams of engineers were starting work on a whole line of other inflatable space vehicles. NASA, Lockheed, General Electric, Goodyear, Martin—everybody wanted to get into the act. At least a dozen types of expandable space vehicles and devices have come forth in the past 10 months since the debut of Echo. Several factors weigh heavily in favor of increased use of these inflatables in our space program. A few are:

1. An inflatable structure made of thin plastic weighs far less than a similar vehicle made of even the flimsiest

metal skin, thus solving payload problems with marginal boosters.

2. Like a parachute, a flexible device designed to be inflated in space can be folded and packed into a small area. Thus an inflatable satellite can be much larger than any pre-formed rigid type that has to be boosted in its original bulky form.

3. Costs of the inflatable craft are far lower than comparable metal vehicles because of the relative cheapness of plastics.

4. Almost any imaginable kind of odd-shaped craft can be lofted to blossom out beyond the atmosphere, whereas rigid satellites have to be restricted to a few basic conventional forms.

Inflatable Researches

Among the proposed inflatable structures now being studied and designed are: 1) drag devices for the re-entry of unmanned vehicles; 2) solar power reflectors; 3) erectable antennae for satellites; 4) recovery systems for boosters; 5) re-entry gliders for manned craft; 6) manned re-entry vehicles; 7) space stations; 8) space

drydocks for repair and maintenance missions; 9) spaceships; 10) extraterrestrial housing for space explorers.

All of these will require reinforced plastic or rubberized skins flexible enough to inflate easily in space and remain rigid after that. In short, they have to be "one way" balloons—able to inflate but not deflate. Several firms, as well as NASA, are researching various materials. The original Echo skin was Mylar plastic 1/5,000 of an inch thick—thinner than the cellophane around cigarette packs—coated with a molecular layer of aluminum. (See offer at the end of this article).

Internal sublimating powders heated by the sun formed the gases that expanded the gigantic balloon in orbit. After inflation, the aluminum coating acted as a thin metallic shell to prevent deflation. This concept proved more successful with Echo than had been expected. When Echo passed into earth's shadow, NASA scientists believed it might collapse as its sublimated gases froze. But Echo held firm. Nor did micrometeorite punctures, which let most of the gases leak out after Echo's return to sunlight, cause the satelloon to deflate.

Somewhat wrinkled, and a bit lopsided from unequalized vapor pressures within, Echo, now a nearly gasless gas-bag, is still circling earth. It has an estimated life of 2 to 15 years. At its launching, NASA dared predict only a year of life at the most.

Even tougher and more rigid fabrics are now being devised. Goodyear's engineers are working on Airmat, a double-walled plastic container. Plastic foam will be blown between the walls so that a hard stiff structure will form in space. They are also developing a sandwiched fabric of finely drawn wire mesh, covered with layers of silicone elastomer plastics and glass enamel, which will resist re-entry temperatures up to 1,500 degrees F.

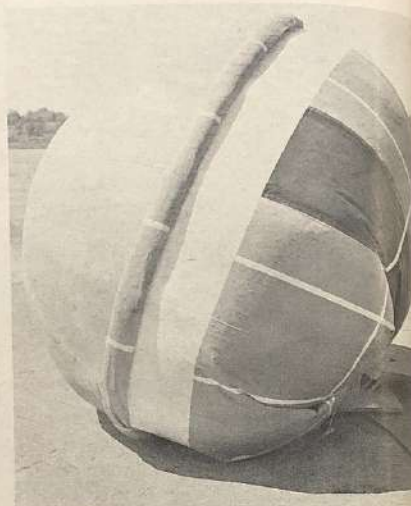
General Electric's scientists are researching a unique "foamed-in-place" process, whereby two reactants are released in space to combine chemically and form a rigid plastic shell around a flexible mold.

The methods of inflation are also undergoing intensive study. New sublimating powders, evaporating liquids, or compressed gases of many varieties are being tried. Goodyear's engineers have worked out an inflation sys-

(continued on next page)



Lightweight, easily packed



Re-entry Drag Balloon

Coated fabric drag balloon capable of inflating in one-tenth of a second is shown in packaged, semi-inflated and inflated stages. The device is designed to control the high-speed deceleration of manned and un-manned vehicles by creating a maximum aerodynamic drag.



and sturdy, inflatables offer space engineers a new challenge

tem that will blow up a 12-foot balloon in 1/10 of a second flat.

Techniques for developing more and more rigid materials are also taking many other forms as research goes on. Engineers at the G. T. Schjeldahl Company, creators of Mylar spheres for NASA, are studying photochemical processes, solar radiation effects, and electrostatic charges on plasticized metal foil, to obtain non-collapsible space vehicle hulls.

Forms and Missions

Since Montgolfier invented the balloon in 1783, lighter-than-air flying craft have assumed a variety of forms and missions. Some of these are the zeppelin, non-rigid and rigid blimps, weather balloons carrying instruments to high altitudes, and huge gas-bags with manned gondolas beneath.

But the new breed of space balloons will be far more diversified. Referring to our previous list and taking them in order:

Drag Devices. NASA scientists are investigating methods of packing deflated objects along with the recoverable payloads that are placed in orbit. Upon re-entry an auxiliary "wing", attached above the returning payload, inflates to provide a wide surface area sensitive to the slightest air-drag in the rarefied upper regions. This will slow down the payload from orbital speed much more rapidly than would any known parachute system, and will also eliminate excessive re-entry heat for the vehicle being recovered.

Goodyear technicians have developed the "ballute", a round balloon having the same purpose as NASA's drag device, and have already delivered small payloads sent up in research rockets. Though the ballute was subjected to speeds which were below orbital, Goodyear's engineers believe a refractorized ballute can be designed to withstand the enormous air-frictional heat produced when objects return from orbit at 17,500 mph. The orbital ballute, after popping out during re-entry maneuvers, will hang on unbreakable strings with the payload dangling below. As both objects plow into thicker air, the ballute's air-drag will mount to high proportions and swiftly cut speeds.

Solar Reflectors. Engineers are also planning inflatables which will unfold as huge, undistorted dish-shaped reflectors when the satellite reaches orbit. The surface, becoming taut and properly curved, will be covered with a bright metal foil to catch the sunlight. This plastic sun-mirror will then perform like a metallic dish collecting solar-power for a generator system.

The engineers at Goodyear believe they can eventually devise inflatable bowls, 100 feet wide, to collect



Inflatable Antenna. Technician demonstrates light-weight characteristic of inflatables that adapts them for space use.

radiant energy for large manned orbiters, moon ferries and interplanetary ships.

Personnel at General Electric Missile and Space Vehicle Division are at work on aluminized Mylar mirrors for conversion of sunlight to electricity in powering systems suitable for all kinds of vehicles. To increase the balloon-dish's useful life against meteorite penetrations, a plastic foam that "seals itself"—somewhat like puncture-proof auto tires—would be pumped within the mirror's double walls.

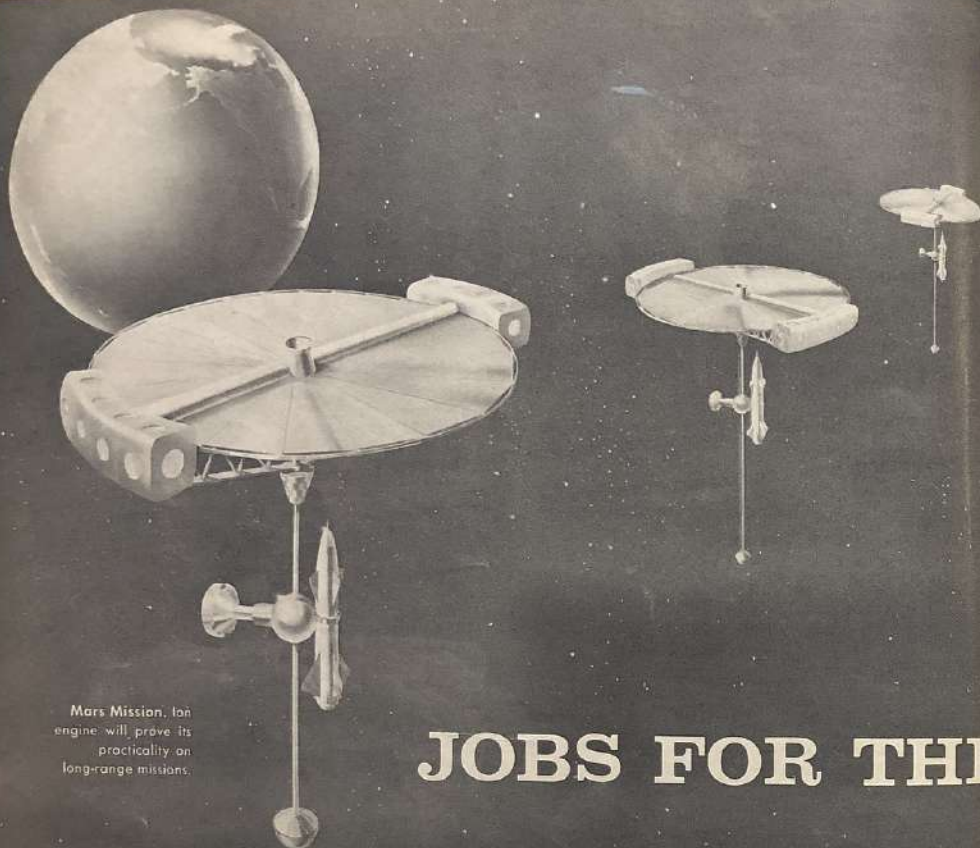
Erectable Antennae. Lockheed engineers are especially concerned with designing various shapes that can unfold in orbit where their metallized outer skins will serve as receiving and transmitting antennae.

They have found that thin aluminum foil by itself, without any plastic backup, can be designed in a pressurized, flat, rolled-up form which will unfurl as long cylindrical tubes. In space orbit under zero-g conditions, the paper-thin foil is as sturdy as sheet steel.

Another antennae system uses plastics combined with aluminum foil which will unfold on top of a satellite

(continued on page 56)

IN



Mars Mission. Ion engine will prove its practicality on long-range missions.

JOBS FOR THE

by ERNST STUHLINGER

If you want to move from one room to the next, your best choice of transportation is your legs. You take a car to the supermarket, and an overnight train if you're travelling from Washington to Boston. A jet plane is probably the fastest mode of transportation between California and the east, but it is far cheaper and far more satisfactory to ship a heavy piece of equipment from Philadelphia to Los Angeles by boat.

It would be illogical to eliminate any of these methods of transportation. Each has its use and is by far the most efficient solution to a particular transport problem. Among flying vehicles, for example, we find balloons, helicopters, propeller and jet driven planes.

The same holds true in the realm of rocket transport. That is why it is unrealistic to speak of one type of rocket system superseding another. We hear that the nuclear rocket will replace the chemical; that the solid-fuel booster is superior to the liquid, or vice-versa; that

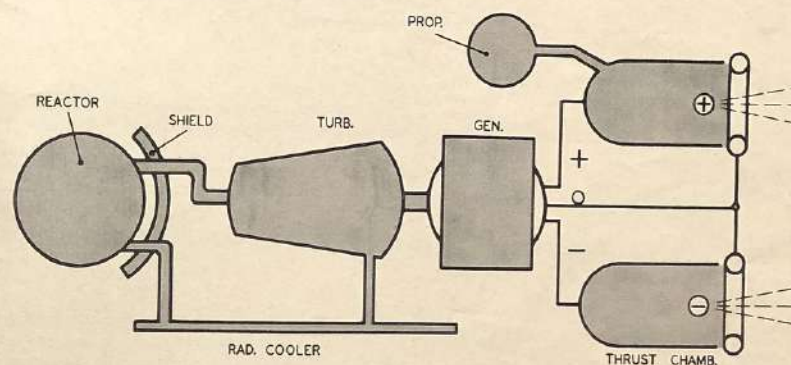
low-thrust ion-engines will make all other rocket modes obsolete. Actually, all of these techniques will contribute to the conquest of space.

The chemical rocket has already proved its usefulness in launching satellites and probes beyond earth's gravitational pull. It has the advantage of generating enormous thrust, but because this thrust is the function of a chemical reaction, it has the disadvantage of a limited exhaust velocity. The chemical rocket cannot accelerate its payload beyond the limits of its exhaust velocity without using prohibitive amounts of fuel. We realize that this factor places a severe limitation on any extended deep-space operation.

We must look for alternatives to supplement the chemical rocket. One of the most promising techniques that is currently being explored—the ion-drive—offers some intriguing possibilities for a solution to this problem.

An ion is an atom that has lost one of its electrons, causing it to become electrically charged. We know that

A distinguished member of Wernher von Braun's staff discusses the capabilities of the Ion engine



Schematic shows basic ion engine components.

LOW-THRUST ENGINE

these charged particles can be accelerated to enormous velocity by a magnetic field. This characteristic is what intrigues the investigators. But we also know that because of the mutual repelling force which the particles generate on each other (like electrical charges repel), the density of flow of the ions will always be small.

Thus, we find the ion-drive creates a situation exactly opposite to that of the chemical rocket. The latter generates huge thrust with limited velocity, while the ion-drive generates enormous velocity with severely limited thrust.

Actually, the principle of the ion-drive has been known for some time now. In September, 1906, Robert H. Goddard, who was experimenting with electrically charged particles at that time, noted that they might be useful for rocket propulsion. Twenty-three years later, Hermann Oberth devoted a chapter of his book *Wege zur Raumschiffahrt* (*Methods of Interplanetary Travel*) to electric propulsion.

Then, in 1946, J. Ackeret, a Swiss scientist, developed

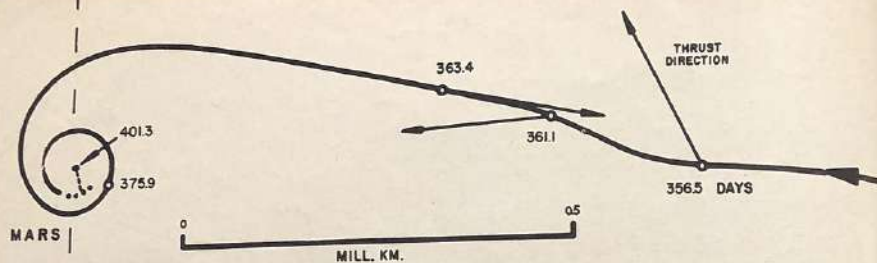
a general theory of propulsion which was applicable to ion rocket engines. After Ackeret, papers on electric propulsion became more frequent. Shepherd and Claver, in England, coined the term "ion rocket" and Forbes, Lawden and Spitzer calculated trajectories of space vehicles powered by ion engines.

With the theoretical basis for the ion-drive firmly formulated, work began on the actual construction of working models of an ion engine. During the past five years, many encouraging laboratory experiments have been carried out and both NASA and private concerns are supporting research and development work on the ion engine.

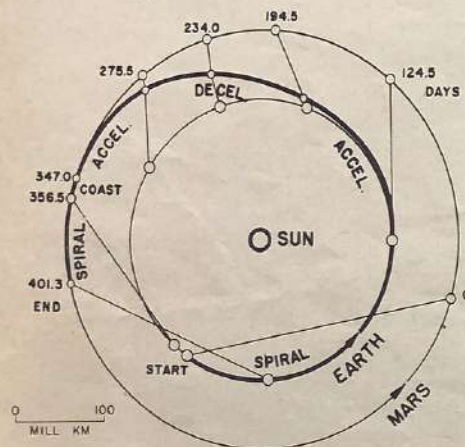
The fundamental distinction of the ion-drive is its high exhaust velocity combined with a low rate of mass flow. The question now is how will we be able to best utilize this unique capacity?

The first thing we must take into account when considering ion propulsion is the low thrust factor. If the

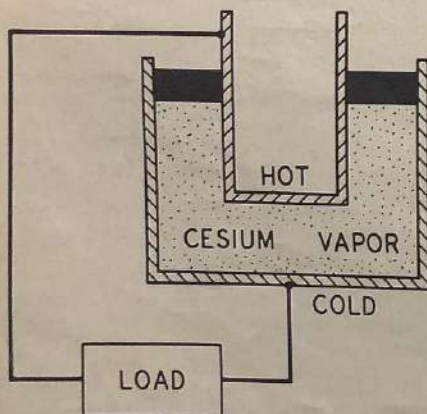
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Mars Trajectory. Ion propulsion, operating continuously, will simplify navigation because adjustments can be made at any time.



Circular Journey. Chart, above, shows minimum energy path between earth and Mars, and relative positions of the two bodies.



Thermo-Electric Unit. Simplified drawing shows unit that could change heat into electricity without a mechanical generator.

First task for the Ion system

system is to produce any sizable terminal velocity, we must allow for a long operating time. In fact, ion drives will be useful only under circumstances where low acceleration and weeks or even years of propulsion time are acceptable.

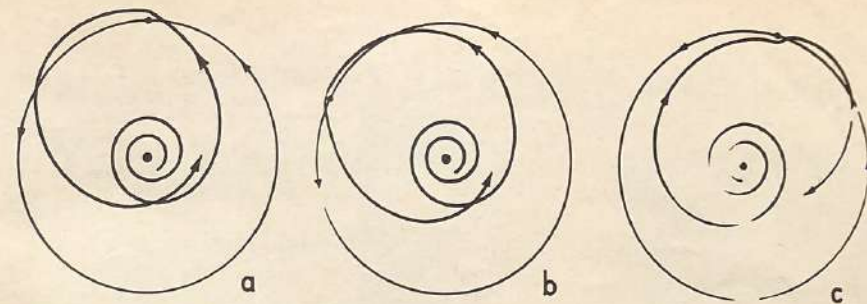
Such circumstances will indeed exist in future space missions. Application of the ion drive, however, will remain limited to the space beyond any appreciable atmosphere, as the ion drive does not have the brute thrust to lift a payload from earth at zero velocity.

Keeping these factors in mind, let us consider some of the tasks that this system can undertake in space exploration. The ion-drive can fulfill the need for a light, small, low-thrust propulsion until that will apply minor corrective forces to keep satellites on a prescribed orbital path with high precision over a long period of time.

The superiority of an ion system over a chemical or even a compressed gas system for satellite orbit control, begins when the total velocity corrections, generated over the active life of the satellite, amount to about 300 feet per second or more. If less total velocity change is required, chemical or jet gas systems will be more efficient.

As time goes on, our earth-bound communication systems will prove more and more inadequate. It is possible that someday the altitude of the 24-hour satellite (22,300 miles) will be a region abounding with heavy communication equipment installed and operated by civilian telephone and telegraph companies. Here we find another role for the low-thrust engine.

While two or three-stage chemically propelled vehicles can place heavy loads into low orbits of a few hundred miles altitude, it takes a powerful and sophisticated multi-stager to put even a modest payload into the 22,300 mile orbit. On the other hand, a low-thrust ion system will lend itself readily to raising a heavy load



Paths For Lunar Approach. A) approach from the rear. B) the direct approach. C) counter rotating orbit. All three of these

trajectories will be accomplished by the use of low-thrust high-velocity ion propulsion systems which are now under study.

will be the lofting of payloads from low to high orbits

from low into high orbit when speed is not a decisive factor.

Beginning operation in low orbit, the ion drive would push the load along a spiral path, while gradually changing its orbital plane to that of the high orbit. Finally, it would adjust the payload to the desired altitude. Having completed this mission, the electric engine system would detach itself from the payload and return on a steep spiral to low orbit, where its cesium propellant could be replenished by maintenance vehicles, so that it would be ready to haul another big package into the high orbit.

On the basis of our previous assumptions (150 watts per pound), this space-lift system may have the following capabilities: a payload package of 50 tons could be transported from a 650 mile orbit into a 22,300 mile orbit in about 23 days, with a propulsion system weighing only 22 tons. The return trip of the "tow truck" would take 6 days. The power plant of the system would develop 4.5 megawatts of electric power.

The vehicle would be guided by a combination of inertial and radio command components. It would be unmanned, but the loading of new propellant and payload in low orbit would be done with human assistance.

One challenging mission for this space-lift system might be the transfer of an inhabitable 24-hour satellite into high orbit, after its assembly in low orbit. The human crew would make the trip in a small, but fast, chemically propelled vehicle, in order to avoid excessive exposure to the Van Allen radiation.

The next logical extension of the ion space-lift will be the ferrying of heavy payloads to the moon. Again, chemical systems can make the trip faster but they are severely limited in payload capability.

A typical ion-drive moon ferry may have the follow-

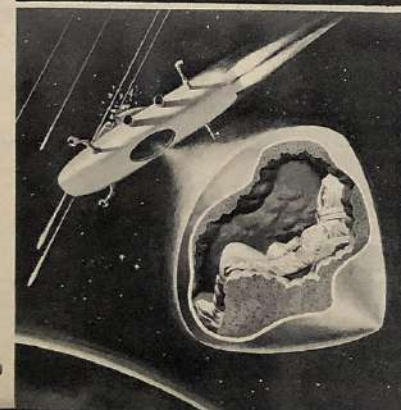
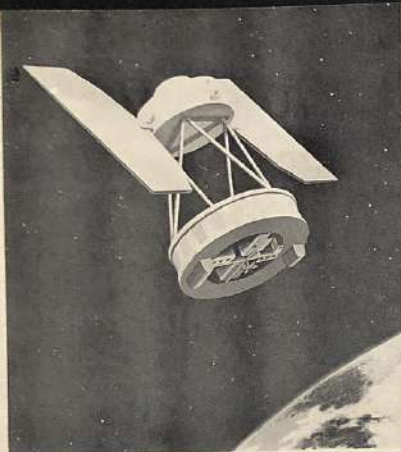
ing design parameters: for a payload of 100 tons, the craft itself would weigh 36 tons. An electric power of 6 megawatts would take the vehicle to the moon in 52 days, and back in about 8 days.

Probably the most challenging mission for an ion system will come when a manned flight to Mars or Venus is proposed. A Mars ship would first spiral around the earth until it obtained escape velocity of 7 mps. From then on, it would follow an out-bound powered spiral around the sun until it covered about half the distance between the orbits of the earth and Mars. Thrust would then be reversed and the vehicle would spiral towards Mars. A few thrust maneuvers to adjust velocity properly would lead to the vehicle's capture by the Martian gravity field. Finally, a close spiral around the planet would bring the spaceship into the desired Martian satellite orbit.

A manned expedition to Mars would probably be made with several vehicles of varied cargo capacity travelling together. Some would carry landing craft for flying to and fro from the Martian surface. Others would be packed with instruments, equipment and fuel for the exploration of the planet. The crew would be in one or several separate ships equipped with life-support systems. Assuming that each vehicle carries a payload of 150 tons, the total initial mass of each would be 435 tons, and the trip from earth to Mars would take about 300 days. The return trip would take 260 days, assuming that 150 tons of payload again is carried, consisting mostly of samples collected on the planet.

It is encouraging to note that the ion ship's travel time to Mars would not be much longer than the 260 days required by a chemically propelled ship. Forty more days for the ion ship should not be significant. The travellers selected for the trip to Mars will certainly

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SPACE ARTIST AT WORK

Roy Scarfo visualizes complex ideas. This is how he does it

by JOHN RUBLOWSKY

Exactly how does a space artist go about his work? Are these admirably realized details of a projected space vehicle merely a function of the artist's imagination, or are they determined by unalterable engineering principles?

To find out, we recently visited Roy Scarfo, art director of General Electric's Missile and Space Vehicle Department in Philadelphia.

We arrived one sunny morning at a rather prosaic downtown office building where an elevator whisked us up to the fourth floor. After the customary security precautions were accomplished, a secretary guided us to the art department where we met Roy Scarfo, with a bundle of rough drawings in his hand, on his way out.

"You're just in time," he remarked. "I'm on my way to a consultation with one of the engineers. Come along, you'll see how a visualization is made. Terrific stuff here," he gestured with the roll of papers in his hand, "a really exciting concept."

Intrigued, we followed him through a maze of corridors, and up a few more flights on the elevator. We stopped at the neat, unostentatious office of Dandridge Cole, advanced systems planning specialist. Roy spread



Consultation. Artist Scarfo, right, goes over details of drawing with Dandridge Cole, advanced systems engineer.

the drawings on the desk and Cole proceeded to a critical examination of the roughs.

Roy, meanwhile, explained the procedure: "All the preliminary work is done with these rough drawings. We go over the details with engineers and don't start on the final version until they're satisfied that everything is in accord with scientific and engineering fact. This way, we're not apt to make a big blunder on the finished art."

Actually, this was the second step in the process. "The first thing we do," Roy continued, "before we start work on the roughs, is talk with the engineers. They explain what they want, and together, we go over each element in the concept, study blueprints or engineering 3-D drawings—if they have them—and get a pretty general idea of where we're going."

At this point, Dandridge Cole, who had been poring over the drawings, interrupted. "This won't do," he said, picking up a drawing of a hollowed asteroid that housed a macro-life colony. "The wheels on the tractor are wrong. They'd work fine in earth's gravity, but remember, there'll be only a fraction of that figure on the asteroid."

He took a pencil and drew a crude sketch of a big-balloon type tire that would be more in keeping with the asteroid environment. "Try to get in something like this," he said.

There were a few more things that needed fixing: a Mars landing-probe has the wrong aerodynamic configuration; earth's perspective would be different when seen from a satellite orbiting at 23,000 miles; a lunar explorer was wearing an unsuitable type of pressure suit.

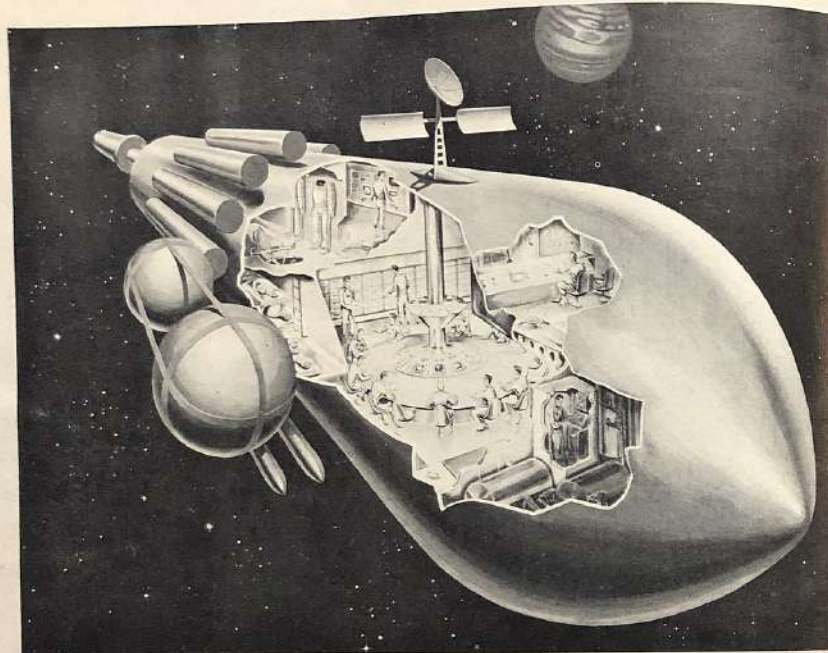
Roy noted all the comments in a small pad, and made tentative changes on the drawings. Consultation finished, we headed back to the art department.

"Should have realized about those wheels," Roy chided himself as we walked. "They were earth wheels and you couldn't expect them to work on an asteroid. You know," he added, an infectious grin spreading over his face, "you can really get caught up in this kind of thing."

At lunch, Roy spoke knowingly about such technical matters as aerodynamic configuration, solar cell arrangement, optimum drag design, etc., and we wondered whether he had had a technical education.

"Not in school," Roy smiled. "I studied art, but I'm

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Interplanetary Vehicle. This visualization was executed from rough engineering drawings and blueprints.

The artist must combine accuracy and imagination



Slo-Mar Model. The author, right, examines model of two-man re-entry vehicle designed by Scarfo and art department staff.

getting my technical education right here. I've been with GE for four years, executing visualizations with some of the top space technologists in the country. In that time something had to rub off."

Roy hails from Pittsburgh where he studied at the Art Institute. He came to Philadelphia when he was called into the service for the second time, during the Korean War. He worked in the Marine Corps Information Office in this city. After his discharge, Roy decided that he liked Philadelphia so he joined the GE Missile and Space Vehicle Department here and settled down.

He now lives in a house in Levittown, a development in the Philadelphia suburbs, with his wife and two daughters.

When we returned to the office, Roy showed us a model of a Slo-Mar two-man re-entry vehicle. It was exquisitely made, with a clear lucite inset that showed the interior cabin arrangement in exhaustive detail.



Lunar Probe. Accuracy of detail in this kind of visualization is achieved by working closely with engineers and designers.

"The shape," Roy said, "is determined by aerodynamic principles, allowing for maximum drag and minimum re-entry heating. This is another part of our job. We design models, like this one, and supervise their construction."

As we were admiring the model, we were interrupted by Joseph C. Hoffman, manager of Production Information for the division, who came in with another engineer.

Hoffman said, "They've changed the appointment date for that presentation."

"We have to be in Washington Friday afternoon," the engineer added. "And we must have the presentation."

Roy started figuring. "267 color slides, 27 charts, 110 visualizations," he muttered. "If you need it by Friday, you'll have to get it by Friday."

The preparation of these customer presentations, we learned later, represents the bulk of the art department's work. In the course of a year the staff prepares upwards of 200 of them. Roy and his staff, working closely with

the engineers, must prepare an exhibit that visually explains the feasibility work of the engineers and scientists. Without this kind of aid, the engineers find it almost impossible to adequately describe and explain their proposals.

This particular presentation was for an advanced space vehicle design that was being considered by NASA. Roy was unable to tell us exactly what it was because of security precautions, but he did say that it was an extremely important project that the GE engineering staff had been studying for months.

Now, all this work had to be condensed into an 8-hour presentation on which an important contract hinged. As the manager, Joseph Hoffman, Roy and the engineer discussed the problem, our idea of the importance of the art department's task was confirmed. As we left, we heard Roy speaking on the telephone:

"No," he said, "don't wait supper for me, I don't know what time I'll be home."

G FORCES

All about gravity—the biggest single barrier
our astronauts must overcome in space flight

by WILLY LEY

Years ago, when the newspapers were full of stories about Captain Yeager and Captain Apt, who both flew faster than sound, the following question was put to me during one of my lectures:

"Isn't it absolutely incredible that a man should be able to stand such speed?"

"Well, let's see," I replied. "Flying faster than sound implies a speed of about 1/5 mile per second since 3600 miles per hour would be one mile per second. No reason why man should not stand this. After all, he is used to moving at the rate of 18½ miles per second."

"What? Where do you get that fantastic figure?"

"That figure," I answered, "is the velocity of our earth on its orbit around the sun. We are all moving that fast yet we don't even notice it."

"But that is something entirely different."

"Why?"

Silence!

Conversations like that do not occur often anymore because artificial satellites have conditioned the public to large velocity figures. However, I am afraid that this is merely a conditioning—like repeated TV advertising—and that the public does not yet know why survival at very high speeds should cause no amazement.

Let's examine the basic principle involved.

From, say, 6000 B.C. until about 150 years ago the fastest a man could move was the speed of a fast horse, or fast dromedary, depending on the region. Then the railroad appeared and there were at once warnings such as this:

"Any attempt to run a train at speeds of 15 or 20 miles per hour would drive the passengers insane; and if the passengers' mental health could be preserved by boarding up all the windows in the carriages, the innocent onlookers would still be driven out of their minds by witnessing such a spectacle." (This is an actual quote from the "opinion" of a Bavarian Commission, written about 1840.)

Well, as we all know, though there have been train wrecks and accidents both at high and low speeds, nobody was ever driven out of his mind—except perhaps over uncertain commuter schedules.

When moving fast in any vehicle on the earth's surface you feel all kinds of things. In the first place there are bumps. You also see things flash by and feel or hear the wind whistling around your ears. The conclusion that at twice the speed you would therefore experience those things twice as intensely is perfectly logical. But that reasoning does not mean the deduction is correct.

In an airplane, for example, the bumps are missing, and nothing flashes by because the ground is far below, and no wind whistles into the sealed cabin. In a propeller plane at 300 miles per hour you feel vibration from the engines, but in a jet at 600 miles per hour you don't even feel that. In fact you often cannot tell whether or not you are moving.

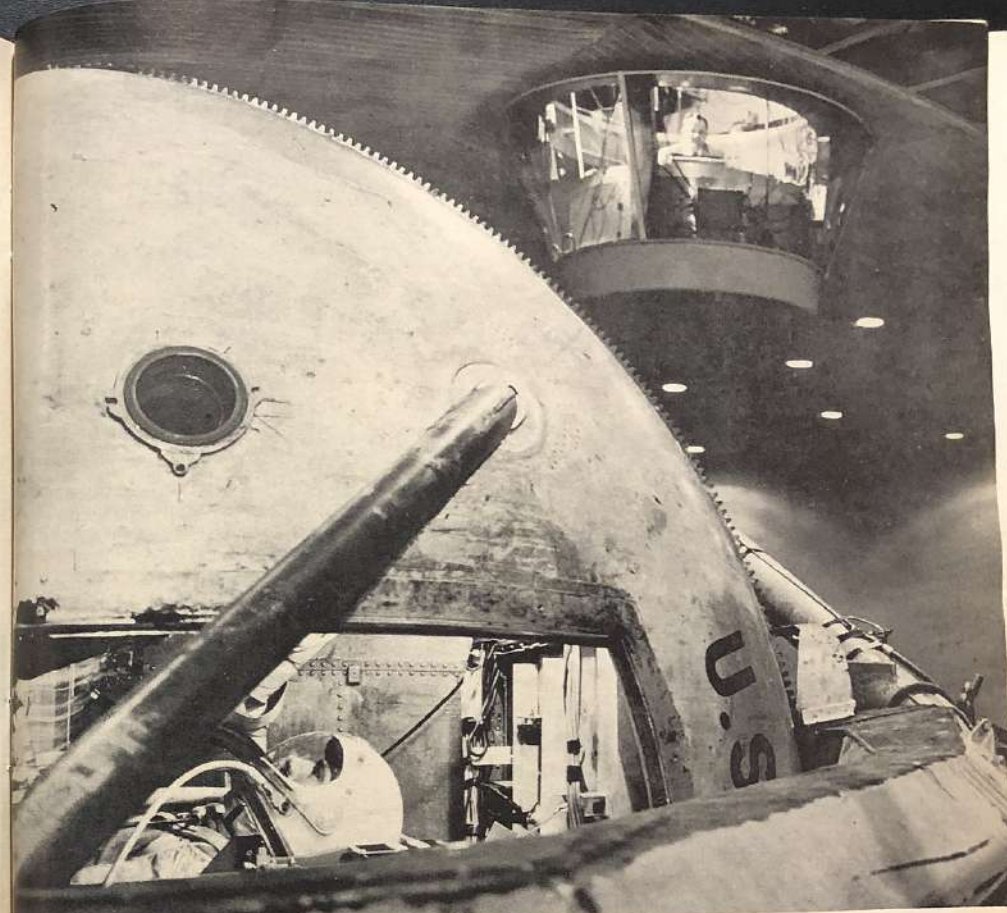
In short, we cannot feel speed. Human bodies lack an organ which serves as a speed indicator. They rely on such secondary information as being shaken up, seeing things flash by, etc., for an impression of speed.

What we do feel is acceleration, an increase in speed. Normally, however, we don't experience noticeable acceleration for any length of time. The sudden speed-up of a car and the take-off run of an airliner are among the few examples known to most people. What happens in the case of an airliner is that the inertia of our body resists the change in speed during the take-off run, but once the airliner is in flight things return to normal. As soon as there is no longer any change in speed our body stops reporting.

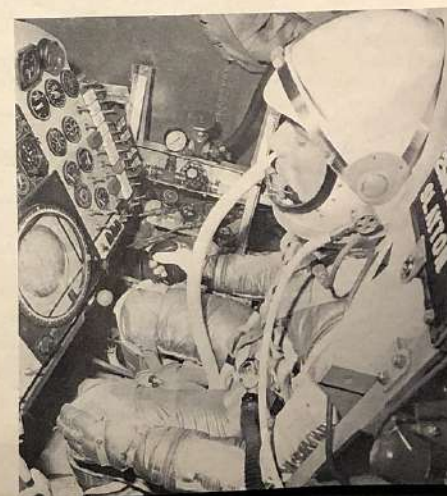
The statement that our body cannot feel speed will probably be accepted in this age of air travel. The next statement is somewhat harder to get across: our bodies also lack an indicator for gravity.

But you might argue that if you stand for two hours, your feet begin to feel your weight. Likewise, if you

(continued on page 61)



Centrifuge. Giant installation at the Wright Patterson Air Force Base simulates the effects of gravity by utilizing centrifugal force. Subject is whirled around in the machine at speeds that will simulate g-forces that occur in launching.



High-G Test. Astronaut Don Slayton, right, undergoes Mercury orbit flight simulation test, under actual launch conditions, in centrifuge cabin fitted with an instrument panel that is identical to that in the actual Mercury capsule.

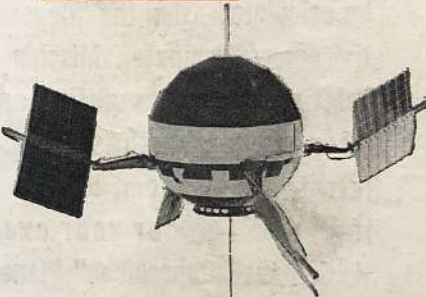
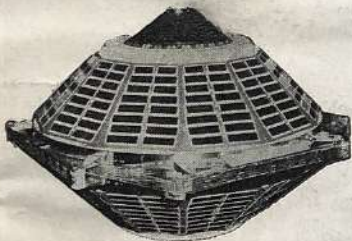
SPACE WORLD

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LIFE ON THE MOON? • ROCKET MAIL • REPORT FROM RUSSIA

IS THERE LIFE ON



THE MOON?

by JOHN RUBLOWSKY

For many years the moon has been held up as a perfect example of a lifeless satellite. Astronomers point to the temperatures that range from a blistering 214 degrees Fahrenheit in the sun side, to the frigid minus 243 degrees on the dark side of the moon. They cite the almost complete lack of atmosphere as proof that life could not exist on so hostile a world.

The moon has been described as a place of complete desolation where nothing ever happens. Where there is no air there can be no clouds, no rain, no sound. Within a dark lunar cave there would be eternal silence and inaction. A spider web, said one astronomer, across a dim recess in such a cave would remain perfect and unchanged for a million years.

This is not a very promising picture for the existence of living things. At first glance, it would seem that the conditions on the moon would be fatal to any kind of native life. But over the years, scientists have not been satisfied with this first glance. They have insisted upon taking a closer look.

Almost 40 years ago, William H. Pickering, then professor of astronomy at Harvard University in Boston and one of our leading selenographers, thought the moon could have life. He based his argument on the observations he had made during a lifetime devoted to careful and painstaking study of the moon. He said:

"The view that the moon is a dead unchanging world . . . is so widespread and so firmly rooted in the minds of not only the general public, but of the astronomical world as well, that the practically unanimous opinions of all the great selenographers has been able to make but little impression on it . . . The arguments on the two sides of the case are very simple. The astronomers who are not selenographers declare that there is no atmosphere or water on the moon and that, therefore, changes and life are impossible. The selenographer's reply is simply that they have seen changes take place on the moon."

Today, observations with better telescopes and instruments lend support to Pickering's ideas. Recent findings have convinced many astronomers that the moon is very far from being a dead and inactive body.

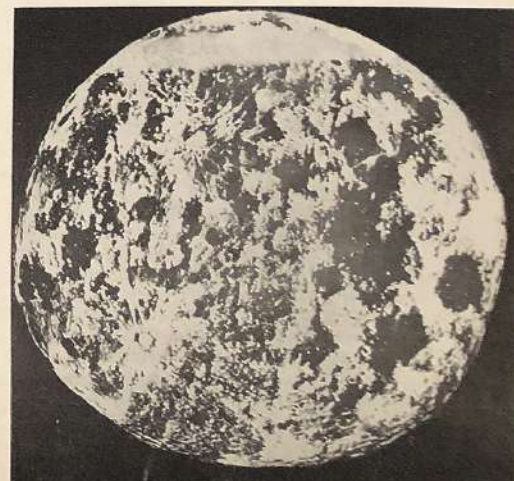
These changes that take place on the moon, how-

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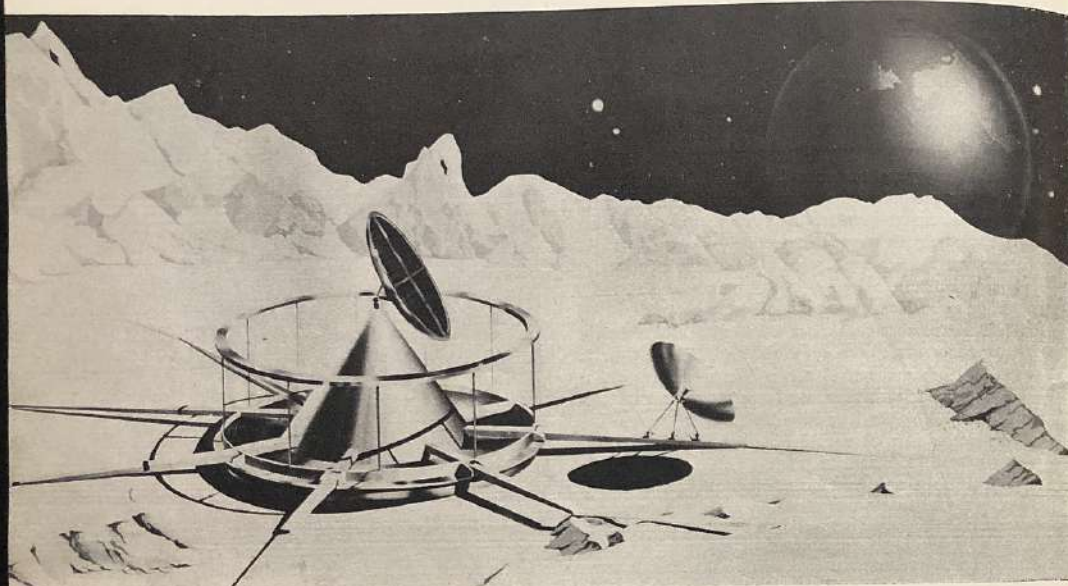
Lunar Landing. Astronomers all over the world are making an intensive study of the moon in preparation for manned lunar expeditions. President Kennedy has set the year 1970 as target date for three-man Apollo mission to the moon.



Modern techniques of radar and telescopic investigation reveal some very surprising facts about living conditions on our 'dead and forbidding' satellite



Some astronomers believe that men will



Unmanned Lunar Probe. A series of unmanned probes are scheduled to land on the moon before manned attempts are made. These probes will investigate lunar conditions at first hand.

ever, have been very hard to see. One of the reasons for this is because of the moon's position relative to the sun. It turns on its axis only once every 27 days—one day on the moon is equal to 27 days on the earth—which is exactly equal to the time the moon takes to swing around the earth. That is why we can only see one side of the moon, and that is why there are no seasons there.

There is no real spring, summer, autumn or winter on the moon. Instead, these seasons are part of the 27-day sunlight cycle. They depend on the play of light and shadow as the sun rolls slowly across the moon's black sky during its long day.

Yet, within the passage of this moon day, what could be called seasonal changes have been witnessed by astronomers. They have seen features on the moon darken, and others turn pale. Still others grow and shrink and change their color in the course of this long lunar day.

The strangest thing about these changes is that they do not keep step with changes in temperature that can be measured between the lunar morning and evening. Instead, these seasonal changes lag behind the sun two

or three days. They seem to keep step with temperatures that scientists expect to find below the surface of the moon, and must depend on conditions below the lunar ground.

If so, then these changes must be the result of vegetation that sends long taproots down below the surface. This would explain the lag behind the sun. But how can we prove it?

It will be very hard to find proof. Temperatures on the moon, for example, are very harsh. They range from 214 degrees Fahrenheit, above the boiling point of water, in the direct sunlight at the equator, to below 243 degrees, a temperature where air turns into a liquid, on the dark side of the moon. This temperature range is far crueller than anything on earth (140 degrees at the equator to -150 degrees in the antarctic) and far greater than the temperature tolerance of any kind of life that lives on earth.

Before we come to any final conclusion, however, let's take another look at these lunar temperatures. We know that the material on the top of the moon is light and porous, a very good insulator that acts just like the insulation we put in houses on earth so that they won't get too hot or too cold.

find life on the moon

And we also know that two feet below the surface of the moon the temperatures are much milder than on the surface. In fact, a new technique allows us to actually measure the temperatures below the surface of the moon.

This is done by bouncing radio waves off the surface of the moon. Unlike light waves, that are reflected from the surface, the radio waves penetrate below. How deep they go is controlled by the wave length of the radio signal. By comparing this reflected radio wave with what was first sent to the moon, we are able to measure temperatures below the surface.

Only two feet below the moon's top, temperatures are much steadier and they don't go up and down more than 80 degrees. But even on the surface of the moon, scientists have found spots where temperatures are not so high or low. Because of the play of sunlight and shadow on craters and mountains, local climates and atmospheres are made. The temperature within the walls of the crater Copernicus, which is almost on the moon's equator, is far lower than the temperatures surrounding it because of this play of shadow.

And these local climates are made wherever there is a walled spot, or a cleft or a hollow in the low areas of the moon's flat plains. Within these protected spots atmospheres are made just like they are made in closed terrariums.

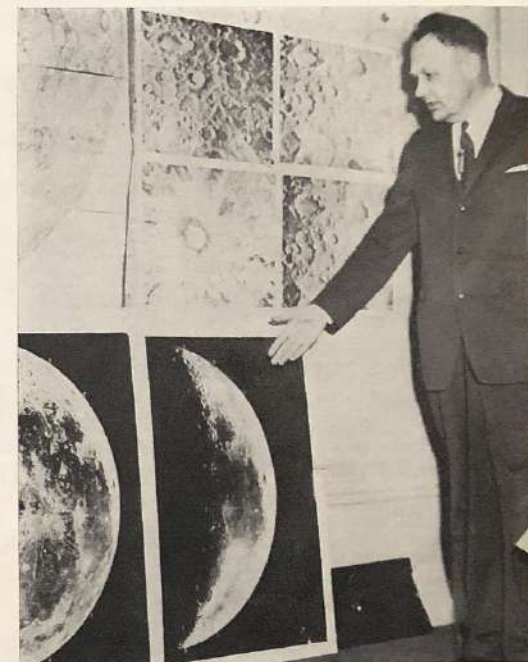
Within such special spots on the moon, many scientists believe, life may have secured a foothold. This life will probably be a very simple form of plant or fungus. But it could have evolved into forms that are completely different from anything we know on earth.

What evidence, though, is there that life developed even in these protected local spots?

"The differences of shade and color between neighboring areas on parts of the moon," says British astronomer V. A. Firsoff, "look suspiciously like a living growth of some kind."

And many other astronomers agree. Patrick Moore, a noted Irish selenographer, for example, says that the round colored bands that run around certain crater walls may be caused by vegetation. These plants, he explains, could have sprung up along invisible breaks in the lunar crust through which life-sustaining gases and vapours from the moon's interior escape.

Such an area occurs in the Mare Tranquillitatis, near the center of the moon. Here, astronomers have noticed large colored patches. The largest of these blue-green spots runs over a range of hills. When you compare these colored spots with the hills surrounding them, you can easily see that the marks are definitely due to something on the surface of the rocks. Some astronomers say that these patches are growths of vegetation.



Lunar Atlas. Dr. Gerald Kuiper, has compiled a comprehensive atlas of the moon to aid future exploring parties.

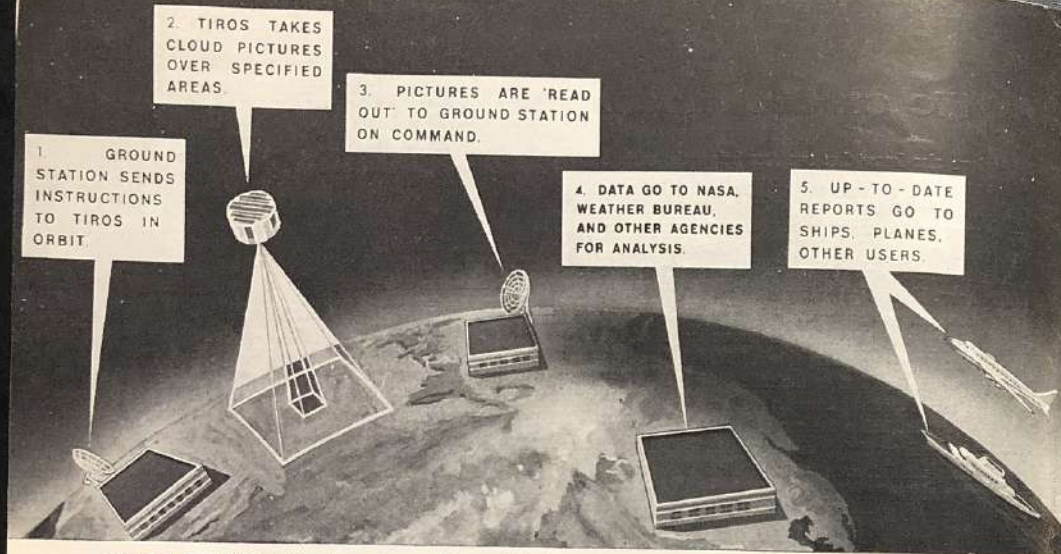
Within the walls of the crater Eratosthenes, still another strange effect has been witnessed. A whole series of dark markings in this area have been seen to grow during the course of a lunar day at the rate of six inches an hour. It is not too likely that these marks are animals moving across the moon, but they could be fast-growing plants.

We have seen that though the temperatures on the moon are fatal to life, there are spots where temperatures are not so deadly, although they are still extreme when compared to earth. Life then, if it exists on the moon, must have learned how to survive this rugged climate.

We also know that the atmosphere on the moon is very thin, as thin, in fact, as the best vacuum we can produce here on earth. And even this wispy atmosphere occurs only during the lunar morning when the rays of the sun vaporize sulphur, bromides, mercury and other such matter that exists in the surface rocks. Moon life then, must have learned how to stand up to vacuum-like conditions.

Also, because of this lack of atmosphere, the un-

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Weather Predictions. Cloud-scanning satellites will help make weather forecasts more reliable than ever before.

What's In Space

A list of benefits that space science is bringing to you



Heart Beat Totalizer. Using space miniaturization methods, this device keeps accurate count of a patient's heart-beat.

Within the next 10 years, the United States will spend up to \$50 billion for both the civil and military space programs. Sooner or later, what our venturesome space scientists learn will affect all our lives—the farmer and the industrial worker on his job, the housewife, the teen-ager at school, doctors, business executives, every citizen.

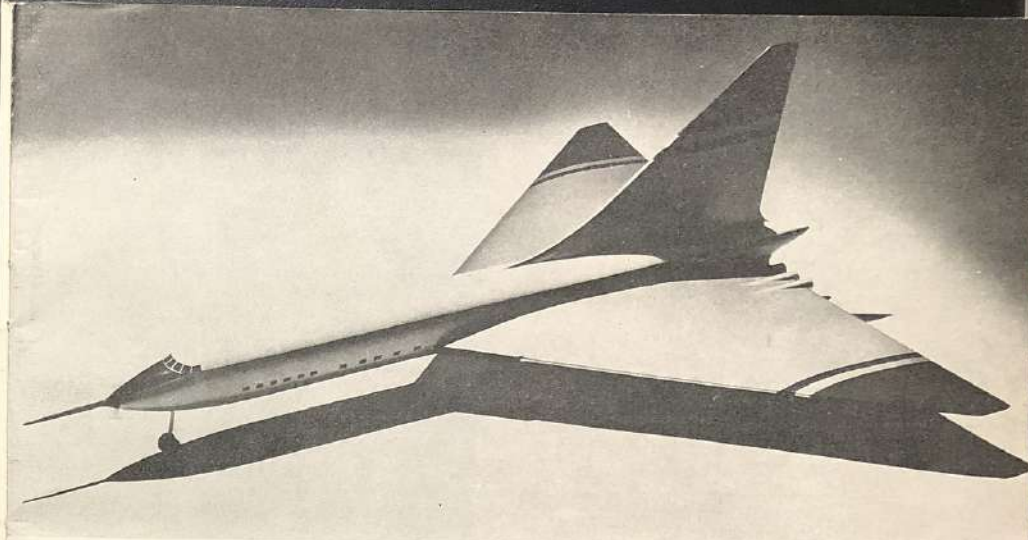
Here, at a glance, are some of the non-military pay-offs we can reasonably expect of our space research and exploration, a small part of the treasure-house of new techniques, new materials and inventions:

Space Communications

On August 12, 1960, NASA's Echo I satellite, a large inflatable sphere, proved it was practical to communicate via an artificial satellite.

On August 18, 1960, the first trans-Atlantic wireless-code transmission was completed via Echo I from the Bell labs to a station at Issy-les-Moulineaux, France.

On August 22, space scientists bounced the first trans-Atlantic voice message off Echo I—a description of the Echo experiment. They also transmitted a recording of "America the Beautiful" from Holmdel to listeners in Jodrell Bank, England.



Supersonic Planes. Techniques of rocket and missile operation will be applied to commercial aviation for super-carriers.

For You?

On November 10, 1960, NASA assisted the Post Office Department in an experiment to determine the possible use of satellites for the transmission of Speedmail. A letter, urging the public to send Christmas presents early, was bounced off Echo from Stump Neck, Maryland to Newark, N.J.—the first letter to be processed through outer space.

In education, relay satellites would make possible "live" regional presentation of lectures and special events, which now must be taped and distributed singly to schools and local transmitters.

Finally, a world radio and TV network should foster better understanding between all peoples and nations on earth.

Weather Orbiters

The meteorological satellite Tiros I transmitted 22,952 TV-scenes of earth's cloud cover up until June 17, 1960. Our Tiros II, launched November 23, 1960, is still active in reporting a whole new spectrum of atmospheric and solar heat radiation data affecting climate and weather.

The Nimbus series will follow the Tiros series in mid-1962. Planned for sometime in 1964 is the Aeros satellite.

(continued on page 46)



Communication Satellite. Courier is prototype for system that will provide radio contact between any two points.

Rockets will soon provide

by WILLY LEY

Will we someday put rocket mail stamps on our letters and see them flashed to all parts of the world in a matter of minutes? Why not, if an ICBM can reach transatlantic shores within 30 minutes and speed half-way around the world in less than an hour?

However, the picture is not that simple. Whether stamp collectors will someday fill a section of their albums with "Space Age Postage", or "Missile Mail Stamps" is as yet uncertain. So far, there is only bona-fide rocket mail stamp, and it commemorates a fiasco.

In Scott's catalogue it is Cuba's No. C-31 of 1939, the then current 10-centavo airmail stamp, normally black, reprinted in emerald green with an overprint: *Experimente de Cohete Postal, Ano de 1939*. This stamp was meant to be used on mail carried by a missile but the only experiment made was a disappointing failure.

This venture's worthy, if over-ambitious purpose, was to demonstrate the feasibility of rocket mail. Instead, it enabled a large number of skeptics to say: "I never thought it would work." Actually, the Cuban experiment was amateurish in concept and poor in preparation. And it was by no means the first try in the world.

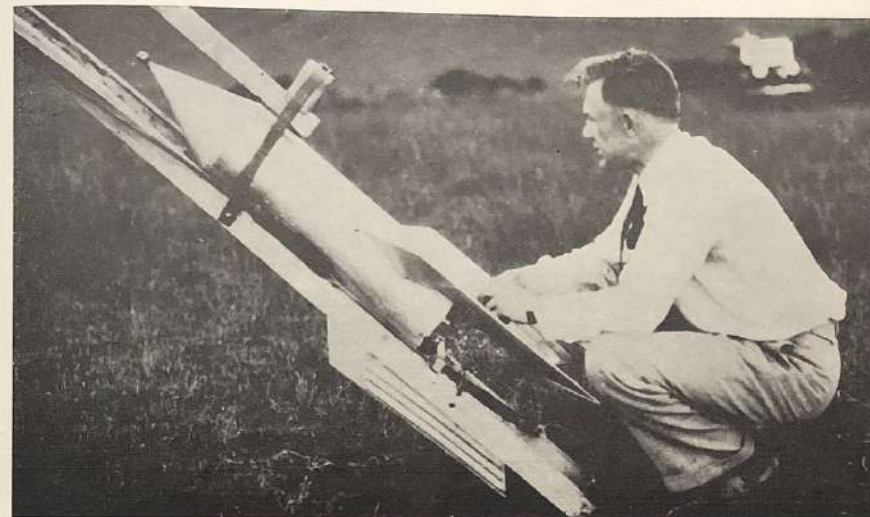
The actual origin of the mail rocket goes back to the 1920s when a group of people became convinced that large rockets, which didn't exist then, could be built. They then cast around for ideas of what to do with such forthcoming missiles. I'm not sure who first had the idea of carrying mail within a rocket. It was either Professor Hermann Oberth or the Austrian physicist Dr. Franz von Hoefft. Since they corresponded with each other a great deal, I don't know who handed the idea to whom.

At any event, both of them publicly came out with it in the early part of 1928. Dr. von Hoefft, in a Vienna lecture in February 1928, said that "the upper stage will carry a mailbag; it should be capable of reaching any point on the globe, along a Keplerian ellipse, in about one hour."

Professor Oberth, in June of the same year, proposed mail rockets with a payload of around 40 lbs, plus parachute recovery, to be shot for distances of 600 to 1200 miles. These are long distances in Europe. He added that this rocket may be put on top of a powerful booster for trans-atlantic mail. He even had recovery of boosters, as well as mail-sacks, in mind so that the rocket vehicles wouldn't be expensive "one shots."

Small mail rockets with less ambitious ranges came upon the scene fairly soon. In 1931 I received a postcard from Austria which besides regular postage bore

one-day mail delivery service to any point on the earth



Early Attempts. German engineer, F. Zucker, above, demonstrated rocket mail delivery in England during early 1930s.

a surprising stamp (not official) indicating that it had travelled by rocket. It was sent to me by a Mr. Friedrich Schmiedl.

From subsequent correspondence with Schmiedl I learned that he was about to establish a regular mail service with solid-fuel rockets of his own design and manufacture. The reasoning behind Schmiedl's work was this: in a mountainous area, like the one in which he lived, two places might be separated by just three miles on a map. But if a mountain was in the way (which was often) and there was no road for wheeled vehicles (which was the rule), the three miles could present a full day's work and climb for the postman.

Schmiedl simply shot his rockets across the mountain in about 10 minutes. When it was on the descending leg of its journey, a parachute was ejected which lowered the rocket and enclosed mail bag to the ground.

Schmiedl's later rockets (in 1932) carried between 200 and 300 letters per trip and the whole operation of his own doing could well be called "semi-official". But in the summer of 1933, the Austrian government stepped in, declaring it unauthorized and enforcing the destruction of the rockets as well as their launching rack.

Though he knew of Oberth's and von Hoefft's prior suggestions about rocket mail, Schmiedl claimed that

even if he had not first conceived the idea, he had definitely been the first to carry it out. He was only technically right. Actually, rocket mail had been in use around the turn of the century in the South Seas, to bridge heavy surf.

The precise place was Niuafo'ou, one of the Tonga Islands. But because the mail cans often split open on impact so that their contents were ruined by salt water, this method had been abandoned in about 1902. It cannot be considered successful, as the Austrian's system was.

If Schmiedl was not the first, neither was he the last. His successor was the German rocket experimenter Reinhold Tiling (who died in 1933 in an explosion in his laboratory). On April 15, 1931, Tiling put 188 numbered and autographed postcards into one of his rockets which functioned well as usual. After him was another German by the name of Gerhard Zucker.

While Schmiedl's rockets worked most of the time and Tiling's almost every time, Zucker's usually blew up. His performance was especially poor in England where he had gone to display the latest example of German inventiveness. After doing just the opposite, he was forbidden by British authorities to try further experiments and was requested to go home.

But the idea, instead of dying, spread widely.

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ROCKET MAIL

OCTOBER 50c
VOL. 1, NO. 17

SPACE WORLD

The Magazine of Space News



40 BILLION DOLLARS - Is President Kennedy throwing it away
trying to put American men into space?



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WILLY LEY REVEALS THE FULL STORY-

The Russian 'Murders' In Outer Space

MACRO-LIFE

PART TWO

by DANDRIDGE COLE

While the most perfect example of Macro Life which can be expected in the near future is the extraterrestrial colony or the giant space ship, other varieties will soon appear on earth. In general these preliminary and experimental steps toward the new category of life forms will lack the ability to move and will probably not be completely self-sustaining because of the ease of resupply from elsewhere on earth. Also, they will not have the ability to reproduce unless special provision is made for this function.

While almost any isolated group of human beings has some of the attributes of the new life form, it is only in some very recent or near future developments that we begin to see the emergence of a new super entity.

Transition forms between the loose colony and the deep space variety of Macro Life (which might be called Astro Life) are: the nuclear submarines, the Antarctic bases, the space simulators under study or development at several defense plants, the underground missile bases, and possible future underwater and underground bases which might be made more completely self sufficient for civil defense and research purposes.

Space simulators have been studied at Martin and General Electric and at other government and industrial laboratories. Work at General Electric on closed ecological systems has produced a water recycling system which was recently used in a test of a full week's duration.

It is now widely accepted that we must begin the task of learning how to live beyond the atmosphere rather than wait for the development of the big booster vehicles that will carry men to the moon. Waiting until transportation is available before starting studies of closed environments would cause unacceptable delays of several years. Thus, we can expect small simulated moon bases to be set up on earth during the next five years.

The crews of underground missile bases must receive the same elaborate protection as the missiles in their charge, if the bases are to have deterrent and retaliatory value. Protection against blast, heat, radiation, chemical, and biological weapons requires that the crews live in sealed underground quarters with adequate provi-

sions for spending the duration of the all-out war in isolation.

Crews of nuclear submarines must also be prepared to spend considerable periods in complete isolation from the rest of mankind. There have already been cases where submarines remained submerged for as long as two months. Presumably, this time could be extended if necessary.

Interest is growing rapidly in various aspects of oceanographic research on a wide variety of problems. The House Science and Astronautics Committee has called for a vastly expanded national effort in oceanography to meet the Soviet submarine threat, and to exploit the untapped resources of the sea. A need has been identified for "open ocean manned research plat-

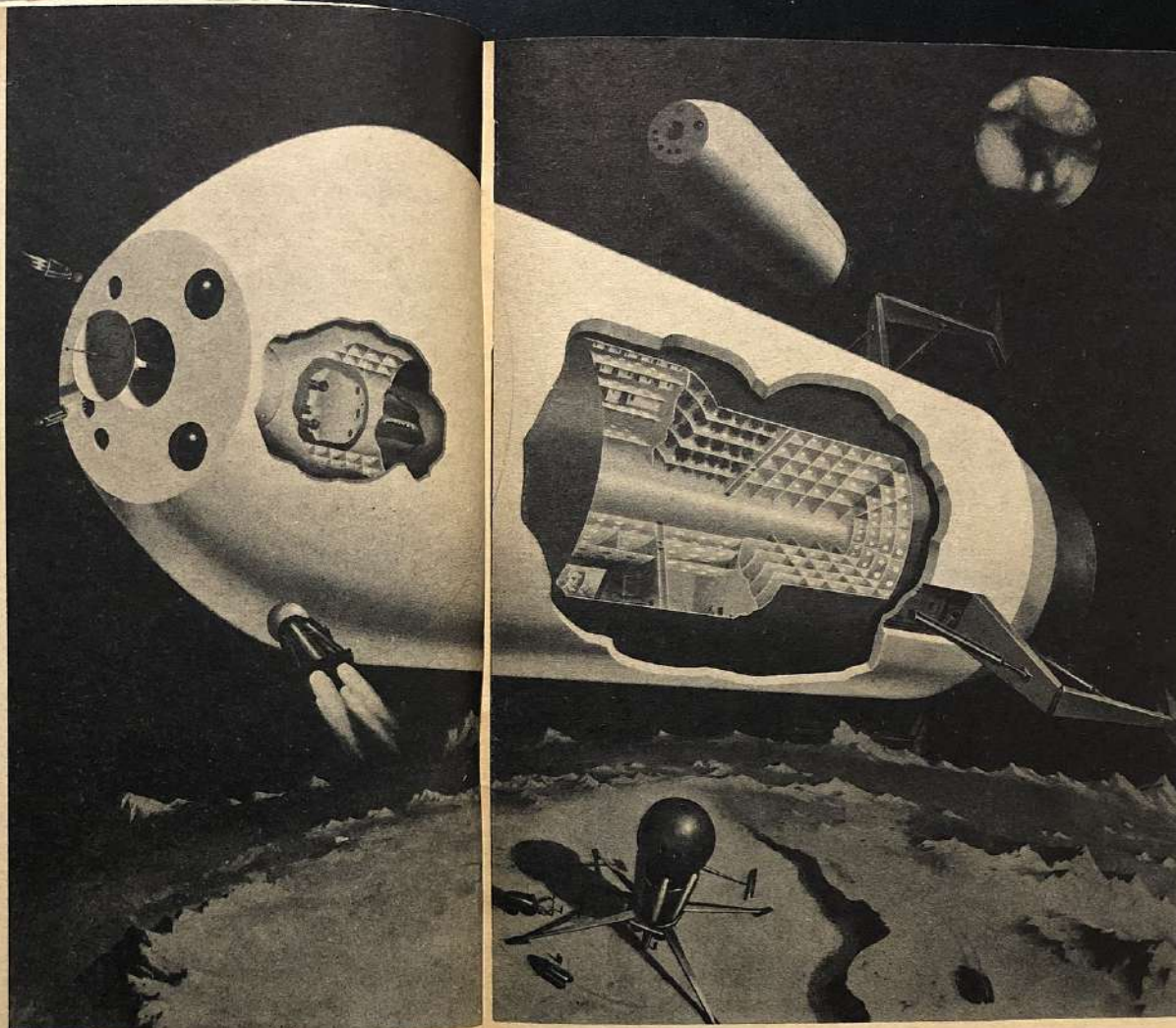
forms" which are stable and can remain in place so that time studies can be made. Considerable interest has developed in new types of research submarines and advanced underwater vehicles.

A possible version of the underwater base could be somewhat similar in construction to the space simulator. That is, it might be a pressurized sphere or cylinder some thirty or forty feet in diameter. The structure could be made almost entirely of transparent plastic for maximum visibility, or of steel with numerous windows. It would be desirable to have a large opening in the bottom to permit entrance and exit of laboratory personnel using Scuba, and possibly of tame dolphins as well!

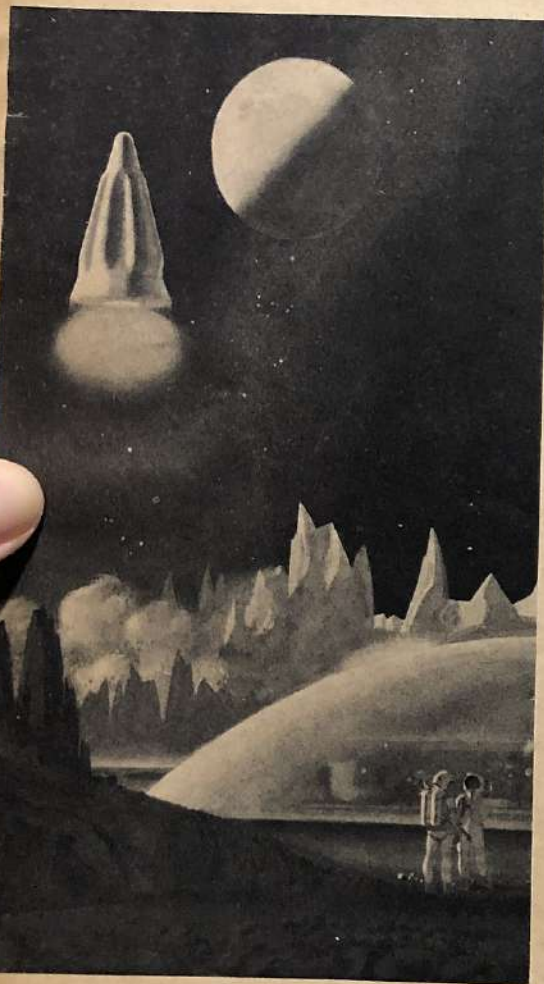
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Exploding population and exploding scientific know-how are the two strongest forces of our time

Macro-life colony is shown in artist's conception. The giant space ship will be completely self sufficient and the inhabitants will be able to build duplicate colonies in order to relieve the pressure of its growing population.



Power for Interplanetary Travel



Lunar Colony. Manned bases on moon will be possible when advanced propulsion systems enable us to loft huge payloads to our satellite on relatively moderate cost-per-pound basis.

New propulsion systems will power future manned probes

by **MAX HUNTER**
and **EDWARD BONNETT**

Advanced propulsion beyond today's technology is the "key" that will open the frontier of space to manned exploration and "shrink" the enormous magnitude of the solar system to dimensions of reasonable cost and travel time.

Two fundamental, technical factors make space exploration much more costly than the conquest of earthly frontiers of the past two centuries. They are: 1) overcoming gravity; and 2) the need for guidance systems with a reaction time far superior to that of man.

Researchers are concentrating on developing propulsion systems of sufficient power to not only launch sizeable payloads but to reduce the degree of sophistication in the guidance, control and ecological systems. In preparing for manned space flight, scientists and engineers have already developed computer systems capable of guiding vehicles unerringly through the void of space. In addition, a spaceship will carry adequate shielding to protect the crew from cosmic radiation, space debris and radiation from vehicle power-sources if they are nuclear. It will also carry a packaged or replenishable (regenerative) earth-like atmosphere, a supply of life-sustaining nourishment and some form of relief for the astronaut's psychological needs.

These systems, plus the explorers, add up to a substantial payload weight which imposes severe requirements on the vehicle propulsion system.

In considering the state-of-the-art in space propulsion, two terms are of key importance. These are:

Specific impulse—this is a measure of the force (impulse) produced per weight of propellant expended, per unit of time.

Impulse-to-weight ratio—this is the thrust capability per pound of propulsion plant weight.



Lunar project. Electric arc propulsion systems, presently under development, will be able to send huge payloads to the moon.

Numerous advanced rocket power systems for deep-space penetration have been conceived, and some are under development. These varying systems differ in basic power source, in method for energy utilization, and in mission application. Studies indicate that to achieve major propulsion gains over the chemical systems of today the energy sources must be nuclear.

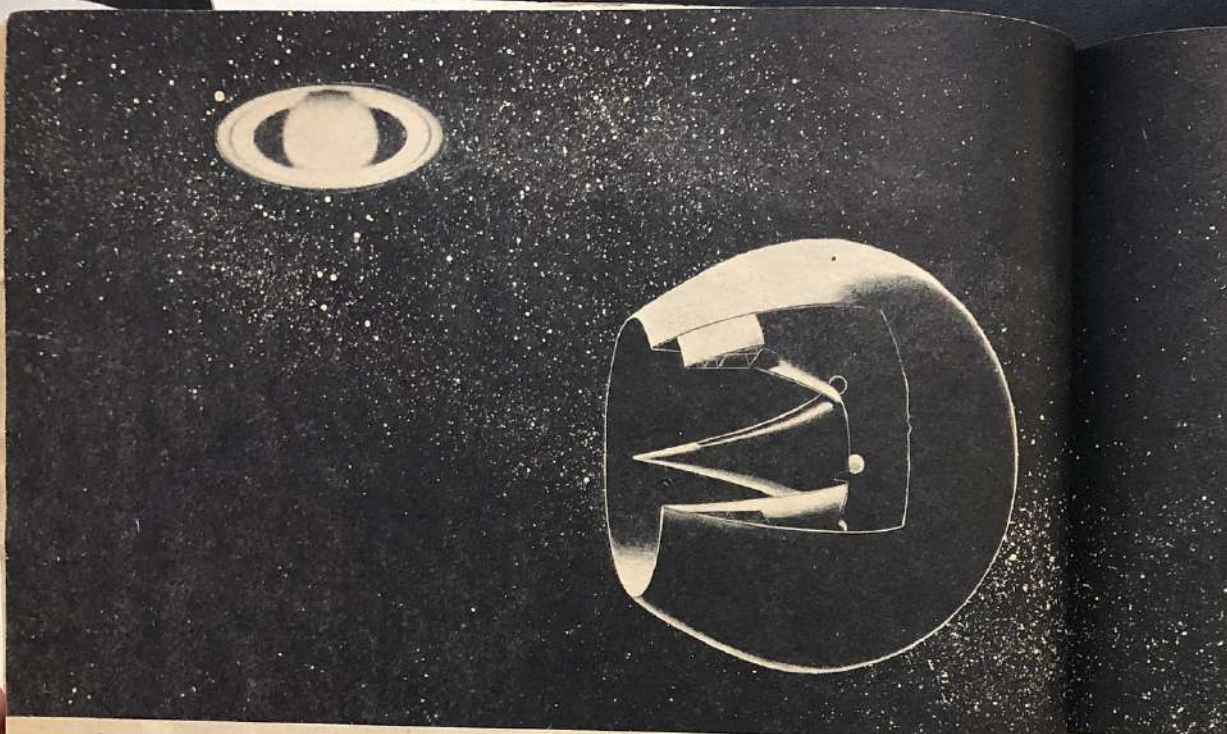
Both atomic fission and thermonuclear fusion processes are promising. At present, quite a few systems for utilizing fission energy are under study. Several may soon reach the hardware stage.

Solid-core systems (nuclear heat plus a gaseous exhaust) will permit fairly ambitious Lunar, Martian and Venusian missions but will lack the performance desired for sophisticated manned interplanetary travel of unlimited degree.

The next advance in nuclear-thrust production might be the liquid-core reactor. This may never achieve the hardware stage because its high-temperature performance range is bounded by the melting and boiling temperature of the reactor's uranium compounds. However, it could, if successful, offer a significant gain in propulsion power.

The typical liquid-core concept is a flow of hydrogen radially through a liquid uranium compound that is held against spinning container walls by centrifugal force. The hydrogen is thereby heated to a temperature near that of the liquid compound—approximately 7000° F.

A propulsion system with a still greater potential is the gaseous core reactor which operates in a hyper-temperature range beyond that of liquid-cores. Two



Saturn Probe. Missions into deep-space will be accomplished with advanced powerplants based on thermo-nuclear generators.

Ion, nuclear, arc jet and photon engines will

types of gas cores are currently being discussed. One of these depends upon centrifugal force for gaseous uranium containment while the other uses magnetic forces to confine an ionized uranium plasma.

Basic problems in the development of gaseous core systems are the magnitude of gas pressure and magnetic field strength required which must be designed down to small size and weight, allow for costly uranium losses and achieve operational stability of the gas-confinement technique. Both theoretical and experimental programs are under way at this time to determine feasibility of gaseous core propulsion systems in the hopes of finding breakthroughs.

Another major class of advanced propulsion systems will be designed to convert thermal energy from a nuclear source into electrical energy, which is then applied to acceleration or generation of high-temperature plasmas composed of ionized particles. Work is under way to develop efficient, reliable electrical thrusts from such super-speed ionic exhaust products. Experiments with such devices are relatively simple to carry out in the laboratory because of the small size and low cost of the required equipment. This apparently is a major reason why these systems are advancing rapidly

to the flight-test stage.

Primaries systems under development for generating electrical power involve nuclear reactors used in conjunction with conventional turbogenerators. Other programs are also under way to utilize thermionic (direct heat-to-electricity) systems in conjunction with reactors. There are many variations of these basic techniques.

The arc jet system. In this device, the propellant gas is heated as it flows through an electrical arc between two electrodes. The gases then pass into a settling chamber where temperature equilibrium occurs before this reaction mass exits through a conventional nozzle to produce the rocket's thrust.

This system is handicapped by the temperature limitations of its materials, much as the solid-core nuclear device. The other drawbacks affecting the arc jet's operating range are energy losses to the device's walls and inefficiencies in the exhaust nozzle.

The plasma jet. This can give a somewhat higher performance than the arc jet. As in all types of these electric devices, the propellant is a partially or fully ionized gas, with negative electron and positive ion densities maintained essentially equal to each other so

surpass chemical rockets

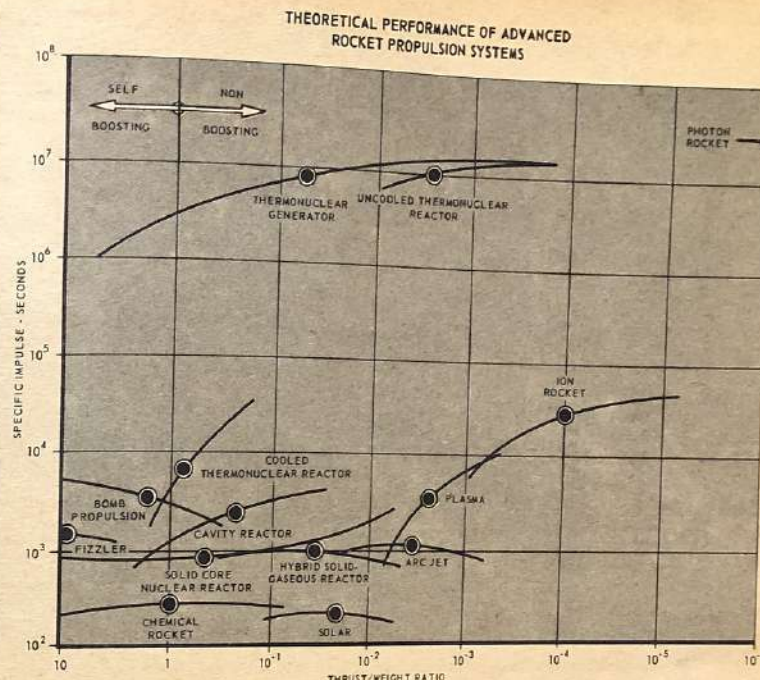
there is no net space charge of either sign in the exhaust mass. The plasma is formed by passing a high current through the propellant gas, which is then ionized by collisions among its nuclei. An electromagnetic field is supplied to accelerate the electrical-conducting plasma particles to high velocities.

Unfortunately, rather high energy losses in the plasma system result from power dissipation as current flows in the external apparatus circuits, plus that used up in the initial ionization of the propellant.

It is not yet certain that the arc jet or plasma thrust will receive much utilization as space propulsion systems.

The Ion Drive. The most publicized of the electrical propulsion schemes is the heavy ion system which appears capable of very high specific impulse. An alkali metal propellant is ionized by a method such as boiling in contact with a hot metallic surface. An electrode accelerates the positive ions to high velocity while they are being focused by a magnetic system. A decelerating grid then enables adjustment in ion velocity.

A beam of electrons must be added to the ion beam to provide over-all system neutralization as it exhausts to produce thrust. This is probably the most serious



Nuclear-Powered Spaceship. Proposed single-stage rocket in artist's drawing will make large-scale lunar flight possible.

must also be protected through the acute attack phase and for many years afterward. Each Macro Life unit should have as a part of its memory the Library of Congress reduced to microfilm. It should have supplies of all the basic tools and machines, and should have representatives of all the major professions, science and engineering specialties, and trades. Some of this could be handled by duplication of function since an expert in one field could also be a master of a second and work it as a hobby. A professor of history, for example, might enjoy gardening and make an important contribution to the colony food supply.

Besides the primary functions of insuring the survival of a viable nucleus of society and in serving as a model for the survival of a much larger fraction of society, subterranean or submarine Macro Life would serve as a model of an extraterrestrial colony, would be an excellent laboratory for much needed sociological and political research, and fill an oft stated need for federal aid to higher education.

In summary, it is proposed that in recognizing civil defense as a major

aspect of the modern defense problem, that the government extend its policy of maintaining service academies into this new cold and hot war discipline. These civil defense academies (and there should be more than one) should be established underwater or underground in isolated areas far removed from military targets. They should have the capability for operating as closed and balanced ecological systems although they would not necessarily maintain this discipline continuously. There would be no need to exclude normal luxury items during peacetime just so the capability for providing all essentials from within the colony itself was always held on "15 minute alert".

These civil defense forms of Macro Life could have all the major attributes of life exhibited by Astro Life itself except possibly that of motion, and even this might be provided in the submarine form. However, they would not have the independence of Macro Life and would always be under the control of the parent state. While they would have the inherent capability for growth and reproduction they would not normally be allowed to exercise these functions ex-

cept in the unlikely event of war.

The resemblance of an extraterrestrial colony to a living being might have some academic interest whether or not such colonies ever become a reality. However, our history and our present behavior both point to the early establishment of such colonies.

The reasons for establishing space colonies go back to the two basic cosmic reactions which have apparently passed their critical points and are now in the detonation phase. These are the detonation of life or "biode-tonation" in the form of uncontrolled human population growth, and "sophidetonation" or the explosion of knowledge. The latter term, derived from the Greek "sophia" for skill or knowledge rather than "sophos"—wise, represents an even greater threat to society than the population explosion, and is increasing at a much greater rate. This is fairly obvious since the expanding population is putting an increasing percentage of its effort into the acquisition of knowledge and is developing greater skill in this acquisition. Society is also just beginning to realize that the statement "knowledge is power" is literally true and that the "armament race" is just one aspect of the "knowledge race".

Population pressure and the drive for new knowledge are two of the primary reasons for space bases and colonies. A third reason, a consequence of the explosion of knowledge is the military need to avoid obsolescence of retaliatory armaments and to push constantly for decreased base vulnerability and increased warning time.

The above reasons can be considered good reasons only if space bases can be constructed at reasonable cost. But sophidetonation and the corollary increase in technological skill can be expected to reduce costs at a very rapid rate. Increase in propulsion system performance, increase in space vehicle size, and recoverability will reduce space transportation costs to the level of present

intercontinental air travel costs in twenty to thirty years. This may seem more plausible if we note that the total velocity change required for a round trip to the antipodes by ballistic rocket is 52,000 feet per second while the total for a round trip to the surface of the moon is only 53,000 feet per second. While many technical problems remain to be solved and while I do not mean to minimize the difficulty of manned space flights, the energy requirements have been greatly exaggerated. Theoretically, an airplane could accelerate to orbital speed and altitude while burning less fuel than is now required for a jet airplane of the same weight and payload to fly halfway around the earth!

Early development work has already started on systems which should reduce the cost per pound transported to orbit to less than one hundred dollars by 1970. With systems which look reasonable on paper this cost could be down to ten dollars per pound by 1975 and one dollar or less by 1980.

Now on the other side of the coin is the cost of the payload itself. If the payload is a rocket propellant for a deep space vehicle, it may cost less than a dollar per pound, thus there will be incentive to reduce transportation costs to this level. However, most space payloads will have a much higher value approaching several thousand dollars per pound for complex electronic hardware.

The payload usually considered to be of the highest value is the human pilot and crew. However, they are not necessarily of any greater economic value to society than the electronic equipment.

Suppose that a space pilot makes an average of \$25,000 per year for forty years. Then one convenient measure of his value to society would be the product of these two numbers—one million dollars. If he happens to weigh 166 pounds, he is worth about \$6,000.00 per pound. While this is a high price, it is of the same

RUSSIAN REPORT

Optimism in Moscow

Since Yuri Gagarin's epochal space flight, Russian scientists, technicians and writers seem to have lost any doubt at all that manned exploration will spread throughout the solar system, and eventually leap beyond into interstellar reaches.

The popular Russian press and the more scholarly journals are full of aggressive, optimistic articles about man's coming conquest of space. Typical is this report by Professor S. Sonnshein, noted Russian physicist, that appeared in the *Literaturnaya Gazeta*:

"Science, as it stands today, gives ample room for the hope that a breakthrough will enable voyages beyond the solar system. . . . If we are to cover the staggering distances separating us from other galaxies, and to overcome the conflict between the life-span of man and the duration of an interstellar voyage, we have to make the speed of the star ship comparable with that of light. This is within the reach of the photon rocket, also called the quantum rocket.

"This type of propulsion system operates on a simple principle: light particles, or photons, recoil from a solar sail in a narrow beam to produce thrust. However, a practical realization of such a device for using photon momentum for propulsion is extremely difficult. For one thing, the requisite beam of photons must be either produced or somehow picked up. Secondly, the solar sail must have a very high reflectance and be transparent to photons or it would melt. Above all, we still have to learn how to control the conversion of matter and energy in conformity with Einstein's relativity theory. As soon as we have learned these things, however, unprecedented horizons will

open before us for space propulsion and travel to distant worlds."

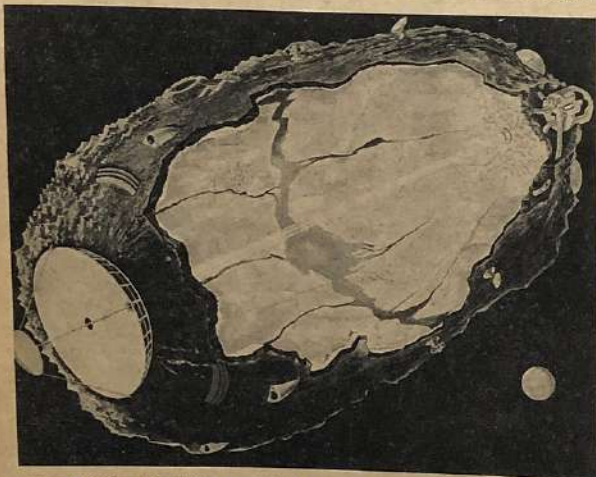
To the Moon

An article in *Komsomolskaya Pravda*, deals confidently with the moon: "The first thing to be built on the moon will be an observatory. The point is that it has no atmosphere to interfere with optical observations as is the case on earth. The ambition of the Soviet scientists is to turn the moon into a mammoth scientific center for the entire solar system. They will train their moon-mounted telescopes far deeper into the universe to peep into the secrets of star formation, cataclysmic processes whose echoes are picked up by the sensitive 'ears' of radio telescopes.

"How soon will all this happen? Is it not too far in the remote future? No, it is not! A few decades will be quite enough for man to accomplish this task. Recall what our country was like 44 years ago. Nobody will dare to say that a nation which has broken away from poverty and illiteracy and into outer space within 4 decades will not achieve its goal."

Unlimited Horizons

And in the same aggressive vein, mathematician V. Krasovsky writes in *Izvestia*: "Today, our Soviet scientists are outpacing the science-fiction writers. We are diverting rivers, leaping beyond the earth and taming the powerful fusion reactions of the sun. Nature is loath to confide its secrets in us. But we wrest these secrets from her. We are learning more and more every day. Unlimited horizons are opening before us. Thousands of roads are leading to the summit of knowledge, and Soviet scientists are marching on every one of them."



Asteroid Colony. Population explosion on earth may some day be eased by building colonies in giant, hollow asteroids where people could make their homes.

order of cost as some of our electronic equipment and also some of the high priced drugs.

Applying this yardstick to Astro Life we may note that the human cells are not of uniquely high cost and cannot be distinguished in this way from some other vital organs or parts. However, the combined value of a colony of 10,000 humans in an Astro being would have an economic value of perhaps ten billion dollars

and might exceed the entire remaining cost of the vehicle.

Thus we can expect space transportation costs which now run close to initial high priced payload costs per pound, to drop down to values approximating initial propellant costs within the next twenty to thirty years. When this cost reduction has occurred it will be no more expensive for a family to emigrate to Mars or the asteroid belt than it now is to

emigrate to Australia. By this time, also, sophidetonation will have provided us with all the knowledge necessary to live comfortably almost anywhere in the solar system, and the emergence of true Astro Life will be technically and economically feasible.

Social and Political Significance

The social and political implications of such basic alterations in our society as have been pictured here could not fail to be of major significance. Whole books could be written describing the nature of future societies resulting from the trends described earlier. Orwell's "1984" and Huxley's "Brave New World" are good examples of what might be done in this field. However, at this time we intend only to make a preliminary survey indicating some of the most basic problems which can be expected to arise with the birth of Macro Life in space and on the earth.

Some of the preliminary forms of Macro Life such as the subterranean and submarine civil defense colonies could appear in the next five to ten years. Initial space colonies may appear in ten to twenty years. True Astro Life will probably appear in twenty to forty years.

During this period life on earth will take on more and more of the characteristics of the space colony and Macro Life, whether or not the fear of nuclear destruction drives large segments of the population underground. The population density of the whole earth will be at the maximum level represented by the efficient space colony in no more than a few hundred years and possibly less than one hundred.

There is a rather strong implication in the preceding sections that the very high density, highly integrated, and efficient society of the future must necessarily have a tyrannical rather than democratic form of government.

Macro Life exemplifies the ultimate society. But we recognize this as a vehicle and a vehicle implies a captain with absolute authority over passengers and crew. It is generally

agreed that the close knit, interdependent society of a ship or a military base could not function effectively with any form of government but a tyranny in the original sense of the word. A democratic government of a ship or a space colony would presumably lead to indecisiveness, confusion, and unacceptable hazard.

However, this is not necessarily the case. We must become more efficient in our social, political, and technological operations as our living space on earth implodes around us and we attempt the colonization of interplanetary space. But increased efficiency does not automatically mean a necessity for relinquishing our basic freedoms. We will lose some of the freedoms we now enjoy, we could lose all of them, but we need not lose our most highly prized freedoms, if we make an effort to retain them.

Our great danger is that we will fail to recognize present trends toward tyranny and will be only half conscious of the slow erosion of our most precious freedoms. The great pressures forcing our society into a more dense and more rigid ultimate form raise doubts as to the ability of the average man to govern himself, and give those seeking power the opportunity to steal a little more from the sleeping public.

In order to have some hope of retaining any of our freedoms, we must do several things and do them soon. We must first of all define and elucidate what it is we want to preserve. We must compare our desires with present realities and future problems. We must order our desires according to preference. We must observe and analyze possible conflicts between freedoms. And we must determine the cost of preserving the most prized freedoms in terms of material welfare, danger to the survival of the race, and loss of conflicting freedoms.

No one would claim that our existing society is perfect or that ours is the best possible form of government in all respects. In evaluating our present treasure of freedom and investigating possible dangers we should not ignore the possibility for

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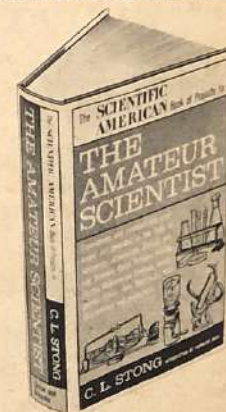
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